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INSTRUCTIONAL VARIATION AND STUDENT RESPONSE: AN EXPERIMENTAL PROGRAM FOR LOW ACHIEVERS IN MATHEMATICS

by

© GAIL BABCOCK

A THESIS

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled "Instructional Variation and Student Response: An Instructional Program for Low Achievers in Mathematics," submitted by Gail Babcock, in partial fulfilment of the requirements for the degree of Master of Education.

ABSTRACT

The purpose of this study was to pilot an instructional program for low achieving junior high school students to determine:

1. the optimum position of teacher explanation/ demonstration in the sequence;
2. advisability of teaching for daily mastery of lessons;
3. effect of socially relevant activities on learning.

The study was also intended to provide insight into extra-instructional factors which influence learning.

The instructional program was developed for the low achiever and as such was designed to include materials of a concrete as well as symbolic nature. Each concept was presented in physical and symbolic embodiments.

Two groups of grade 7 and grade 8 students were chosen and both groups received lessons covering the same topics: geometry; linear measure; and operations with signed numbers. Each of the three cognitive variables was studied during a single phase and conclusions were based on achievement test scores for the two groups, teacher response to alternate treatments of each variable, and student responses as recorded in diaries and during personal interview.

The teacher explanation/demonstration appeared to have a dual function. It served as a set of directions which indicated how students were to proceed with a given activity. These

directions may also contain rules or relationships to be discovered. Findings indicate that whereas all instructions and questions being answered by the activities must be given prior to an activity, a statement of relationships is probably best left until activities are completed.

The results with respect to the other two variables were less clear. Mastery of daily lessons was difficult to assess but evidence suggests that repetition of lesson content does increase retention. It would also appear that activities of a socially relevant nature facilitate transfer of structure from activity model to mathematical model.

Students felt they understood questions better when physical activities were available and enjoyed working in groups. All students wished to continue learning math using activities but most believed the "old math" (fractions) could never be learned this way.

Two influential extra-instructional factors were noted in student diaries. Marking on an individual basis was found to seriously inhibit cooperation during a lesson and students were inclined to judge a lesson by their perceptions of the teacher that day.

It was concluded that an instructional program involving the approach above merits further trial and the three selected variables as well as extra-instructional variables merit further study.

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CHAPTER I

THE CURRENT PROBLEM

I. INTRODUCTION

A great deal of attention has been given to the development of new teaching methods in mathematics over the past fifteen years and programs for the average and above average student have been the subject of much experimentation by mathematics educators. Experiments concerning the teaching and learning of structure have been carried out on "good" students who have been able to articulate meaningful responses to the experimenter. These students have facilitated progress on various instructional and learning theories by virtue of their ability to verbalize their reasoning in mathematical experiments. (Brownell, 1963)

In the flurry of activity one group has generally been ignored. Those students who score below the 30th percentile in mathematics achievement, often low achievers in other subjects as well, have been penalized for failure to perform adequately. Conferences on the low achiever have been characterized by discussion of a descriptive nature. The question has been "who" is the slow learner and very rarely "why" is he a slow learner? Experimentation done in the individual classroom has often been fragmentary in nature with activities introduced as desirable

ends in themselves rather than to determine where in the instructional sequence such activities would most beneficially be introduced. Very little or no in-class experimentation has been done to determine the learning needs of the low achiever in terms of his developing intellect. For example, experiments to determine the power of different modes of conceptual representation have not been carried out on large groups of low achievers in junior high mathematics.

The literature abounds with studies revealing the need for remediation with fundamental operations at the junior high level. There is also an abundance of research to indicate low achievers are operating concretely and need physical representations of mathematical concepts. The massive failure of these students to cope with algorithms at an elementary level and a parallel failure of the school system to provide alternate methods of achieving the mathematical objectives has resulted in a large proportion of students in need of remediation. It has been recognised (Lovell, 1961) that low achievers are behind their counterparts in terms of intellectual development and this information must be utilized in refining the instructional program to meet their needs.

The qualitative differences which exist between low achievers and average students with respect to self-concept unquestionably effect progress in the cognitive domain. By way of definition, self-concept is:

> . . .the person's total appraisal of his appearance, background and origins, abilities

> and resources, attitudes and feelings which culminate as a directing force in behavior. (LaBenne and Greene, 1969, p. 10)

One manifestation of the self-concept is behavior in the academic setting. It is significant that students develop a concept of self which draws largely from perceptions of what others think of them. In the academic situation the most significant others are fellow students and teachers. By the time he reaches junior high school the student's self-concept has been reinforced by many years of success or failure. The low achiever has labelled himself a failure and established his expectations accordingly. Likewise his poor attitude toward school in general and mathematics in particular makes the low achiever an undesirable subject on whom to pilot experimental programs.

More and more money is being paid out for education but the educational product has not shown a corresponding growth. (Lieberman, 1970) The drop-out rate is increasing and the students who leave school before graduation are from that group which falls below the 30th percentile in over-all achievement. One recent response to the drop-out rate and illiteracy problem has been pressure for accountability in education. The implementation of performance contracts in the U. S. was undertaken initially as a last resort in the war against academic failure. Concern has been shown not only by professional educators but the government and public in general. (Stucker, 1971) If the educational system is to be a success, in fulfilling an obligation to the public it serves, some answers must be found

to the problems of the low achiever--not just who he is but why he is and what can be done to give him success.

II. THE PROBLEM

The purpose of the study was two-fold. First, it was intended to explore a specific instructional program to determine those factors which contribute most to academic success. Stated in three parts:

1. Does the position of teacher explanation and demonstration of a concept in the instructional sequence effect achievement scores? Is there an optimum position in the sequence?
2. What is the nature of the effect on achievement test scores by students who master each lesson when compared with students who do not master each lesson?
3. Does the lesson's context effect achievement test scores? Does the student who receives a socially relevant (related to his own experiences) presentation compare favorably with the student who receives a purely academic treatment of the same concept?

Furthermore, use of physical materials and permitting students to work in small groups were two basic ingredients of the program. An attempt was made to determine the success of incorporating these items.

Secondly, it was hoped that through a combination of student response in diaries, personal interviews with students, and teacher response to various aspects of the program, some insight would be provided into the interrelationships of student characteristics and an instructional program of the type proposed. Specifically, the researcher hoped to determine which of those characteristics peculiar to low achievers would facilitate learning and which proved to inhibit learning.

III. DEFINITION OF TERMS

For this study the following meanings will be associated with the given terms:

Slow learner: Any student who has a measured I. Q. less than 90.

Low achiever: Any student who is achieving at or below the 30th percentile in mathematics in his school.

Teacher explanation/demonstration: Teacher lecture or presentation with the intention of providing the student with concepts and relationships of an abstract nature.

Mastery: Achievement of lesson objectives by approximately 80% of the class or more as evidenced by correct completion of daily lesson exercises.

Social relevance: Pertaining to the context or activities of a lesson, those to which students readily relate in their daily experiences.

Instructional sequence: The order in which the various instructional devices are incorporated into the daily lesson. For this study we are concerned specifically with the order of physical embodiment and teacher explanation in the development of each lesson.

IV. THE EXPERIMENTAL SETTING

Two groups of students were formed from special sections of grade 7 and grade 8 classes in one Edmonton school. An entire class of special grade 7 and six special grade 8 students were included in the study.

The study was implemented during the regular class time every day for approximately six weeks. It was divided into three phases to facilitate inspection of the three problem areas:

1. teacher demonstration: phase I--expected to last 2-3 weeks.
2. mastery: phase II--expected to last 2 weeks.
3. socially relevant activities: phase III--expected to last 1-2 weeks.

The researcher instructed group I and the special grade 7 teacher instructed group II for the duration of the study.

V. DELIMITATIONS

Nature of the Sample

Students who participated in the study were from special sections in mathematics. All were low achievers in the general school program. A majority of the grade 7 students were suffering some degree of language handicap with three students unable to speak English. Many of the students lived in homes where English was not the spoken language.

The sample was divided into two groups with the six grade 8 students confined to one group.

Duration of the Study

The study was designed to cover six weeks. A variety of unforeseen events such as special vacations, extra-curricular activities and teacher absence combined to increase the actual time to just short of eight weeks.

Topics and Materials used in the Study

The Special classes had been following a textbook development which focussed on remedial topics such as operations with rational numbers. Essentially no physical activities or laboratories were used in instruction and treatments were generally abstract. Unfamiliar topics were introduced with this study under the assumption that student responses to

variables under investigation would not be contaminated by prior exposure. Plane geometry was developed over the first two phases of the study and linear measure and operations with integers were introduced in phase III.

VI. OUTLINE OF THE REPORT

In this chapter the problem and its context have been discussed. Chapter II will provide a theoretical framework from which the instructional variables were drawn and includes a review of literature having direct bearing on the topic of the low achiever. Chapter III includes a description of the instructional program and a design for studying the dependent variables. The Chapter also includes a discussion of provisions to be made for studying student responses other than those directly measurable in terms of achievement tests. Chapter IV includes results from the planned experiment and Chapter V was devoted to a report on student responses to the experiment. Chapter VI is a summary of findings and includes conclusions and implications.

CHAPTER II

THE THEORETICAL POSITION

I. INTRODUCTION

In this chapter an attempt will be made to develop an instructional framework for the low achiever. Thus the chapter will examine existing theories related to mathematics instruction and to the low achiever and seek relationships between them. The first part of the Chapter will include brief summaries of relevant theories. A second part will contain a discussion of who the low achiever/slow learner is and will dwell especially upon that group of students who are behind their counterparts from a developmental point of view. The present report is concerned with the junior high student and thus this chapter will focus on that particular age group, roughly from twelve to sixteen years of age. Included is a review of current research and those programs that have implications for the low achiever/slow learner. Finally, an attempt will be made to synthesize the information into an optimum instructional program for the low achiever. This theoretical discussion will include an explanation and description of concept presentation which, when considered as an outcome of the foregoing theories and findings, should provide an effective means by which to present mathematical concepts to the low achiever in the junior

high school.

II. THEORIES OF COGNITIVE DEVELOPMENT

Fundamental to the structurally based theories of learning and instruction of mathematics is the developmental theory of Jean Piaget and the Genevan School. Piaget sees the development of a child manifested in four stages, unalterable in sequence and necessary for the complete development of the child. The stages are:

sensori-motor - generally in effect until 18 months of age.

pre-operational - ending around 7 or 8 years of age.

concrete operational - effective usually until early adolescence.

formal operational - characterized by the adult ability to reason formally.

Age boundaries have been set by Piaget with a great deal of latitude. The boundaries are subject to cultural influence (Piaget, 1950) and cannot be assumed for every individual within a group.

Piaget views intelligence as developmental according to the four stages and sees the progression as facilitating further adaptation of the individual to his environment. The individual is believed to have developed a mental structure, or schema, through accident, design, or both, which is exposed to continuous

influence from the environment. Any stimulus which is readily accepted into the existing schema is assimilated. That stimulus which does not readily fit existing schema will precipitate growth of a suitable structure. The process whereby a new schema emerges is referred to as accommodation. The difference between assimilation and accommodation is one of a confounding effect and learning, or adaptation to one's environment, is effected when both assimilation and accommodation are occurring with exposure to external stimuli.

The stage of development which characterizes the individual is determined by the degree to which he is able to operate upon objects. The child progresses from immediate physical actions on objects, through the hierarchy of stages, until he is able to operate on ideas. This is manifest in the stage of formal operations where concrete materials are no longer necessary as operative devices. The significant ability is that of interacting with an object at greater and greater spatio-temporal distances (1950). That is to say, development of the intellect will reach its logical conclusion when the individual is able to interact with an idea as separate from a physical embodiment. He operates and reverses the operation internally, and without need of a concrete embodiment.

In relating his psychology of intelligence to the cognitive task Piaget (1964) asserts that learning is subordinate to the sequential course of development. The implication for education is that a child needs concrete materials to learn concepts until

he is able to operate on ideas alone (Flavell, 1963). The actions on the objects must become interiorized before the child has knowledge and the child must "know" the physical properties and operations before he can operate on the abstractions.

Of those who follow the principles of developmental psychology as set forth by Piaget, Jerome Bruner has made significant contribution with respect to the development of mathematics learning. Fundamental to Bruner's Cognitive theory (Bruner, 1966) are the possible ways in which a concept may be conveyed. These ways he calls the modes of representation and distinguishes three types. The enactive representation involves physical activity which conveys a perceptual understanding of the concept. Ikonic representations are those which consist of images or models of the concept and which are perceptually apparent to the individual. The third mode, symbolic representation, is characterized by a description of the concept using symbols. This association of symbol and idea may not be perceptually obvious. Symbolic representations require a store of images with which they can be related in order for the individual to understand his manipulations of the symbols.

The parallel with the Piagetian stages is striking and Bruner (1964) has suggested that, in fact, the learning of a concept probably progresses naturally through the three representations. An individual may experience a concept spirally, beginning with the physical and ending with the symbolic, or he may bypass the first one or two representations and deal directly

with the symbolic (Bruner, 1960). The obvious problem with presenting concepts symbolically is that the underlying assumption that a concrete association exists may prove false. In this event the symbols may be memorized but learning will not take place. The implications for education is not simply one of the most suitable mode of representation for a given age; it also suggests the need for a repertoire of suitable images before a concept can be developed in its abstract form. In the Piagetian sense this might logically mean that a mathematical concept be presented enactively to children in very early grades, again embodied in models and finally, probably at the high school level, in its most symbolic form. Bruner believes that the concept may be developed with certainty only if the mental imagery is available but that the images may be introduced immediately prior to the symbolic representation. The sequence of representations is the critical issue and on this Piaget and Bruner seem to agree.

Another psychologist-mathematician whose research shows the Piagetian influence is Z. P. Dienes. Originally, Dienes (1960) saw the development of a concept progressing naturally from a random play stage, through directed play, and on to arrival at the abstract idea which is then analyzed and reflected upon. The final stage is characterized by practice with the idea.

Following a study with Bruner at Harvard, Dienes (1963) modified the cyclic structure formulated above and related the sequence more to personality factors and characteristics of

materials used. He found that unstructured and structured play, previously thought to be in strict order, were in fact highly variable in order of occurrence. The development of concepts will occur naturally according to the above stages which Dienes calls "games".

Arrival at a mathematical concept will be facilitated by the adherence to certain principles. The Multiple-Embodiment principle stipulates the concept be presented in many different physical forms. This insures that the idea will be abstracted in a pure form and not in association with a concrete object. The Dynamic principle states the need for direct manipulation and physical involvement with concrete objects. Essentially, the student will not abstract the concept until he has "played" with the ideas and arrived at an insight. The Mathematical Variability principle stresses the need for varying all variables. The student will not easily recognize that which remains fixed unless it is placed in a variety of contexts. A recent study by Dienes and Jeeves (1970) has provided evidence to support varying the symbolism used to label abstractions. The traditional belief that a single symbol system is advantageous to learning has been seriously challenged. Rather, evidence suggests that more than one symbol system be developed for a situation and each system studied in a variety of settings. Thus the symbols would be appreciated as part of an abstract structure and not the particular situation.

Dienes found some problems with the implementation of the

Multiple-Embodiment and Mathematical Variability principles. (Dienes, 1963) It was found that providing too many embodiments proved confusing to "better" students and the excess embodiments were thought to contribute too much "noise" for abstraction to take place. The Mathematical-Variability principle (application of) presented the problem of how many variables can be manipulated at once. It may be that some students must be provided very few variables and the number increased only when generalization has taken place.

III. CHARACTERISTICS OF THE LOW ACHIEVER/SLOW LEARNER

Definitions

The current study is concerned with the student who is working below grade level in mathematics. Various descriptions and distinctions have been made by researchers but two distinct categories emerge from the literature.

Potter and Mallory (1958) define the slow learner as one who has an "I. Q." between 70 and 90. They view this as an inherent attribute, unaffected by nurture.

Marilyn Suydam (1971) divides that group which is working below grade level into two classes. The first she labels "environmentally disadvantaged" (culturally deprived). This group presents a special subset of problems which tend to prevent proper measurement of abilities, making diagnosis for inclusion into an ability group very difficult. Certain cultural factors

influence I. Q. and thus I. Q. may not be a valid criteria by which to determine ability within this group. The second subgroup Suydam labels "academically disadvantaged" and further divides this into those of low intellectual ability and those below average in achievement. In the latter group are the low achiever and under-achiever, both characterized by a potential for greater achievement following remedial work. The group characterized by low intellectual ability, slow learners and the mentally retarded, differ in that achievement level will not increase following remediation.

Younie (1967) labels slow learner all students whose intellectual development has been retarded and so cannot meet the academic requirements and expectations placed on him. There are five subgroups defined:

1. the underachiever
2. mentally retarded
3. sensorily impaired
4. emotionally disturbed
5. culturally deprived.

The slow learner who is most frequently encountered in the classroom Younie describes as having an I. Q. between 75 and 90 and achievement scores 1½ - 2 years behind grade level. These students constitute approximately 15-20% of the school population.

Beilin and Gotkin (1964) in researching the slum child found him to be on the average about two years behind his middle

class counterpart in terms of intellectual development.

Max Sobel (1965) defines the slow learner in terms of local associations. The student who ranks below the 30th percentile in mathematics by standards set at the local level is considered to be a slow learner. Generally, I. Q. will be between 75 and 90 with a mean of 85.

Gerardi (Woodby, 1964), in discussing the Junior High school student defines the slow learner as one who:

1. falls below the 30th percentile in achievement.
2. has an I. Q. between 80 and 90.
3. has a reading level at grade 4.
4. has a record of poor achievement in all subjects.

Leiderman (SMSG, 1964) defines the slow learner as any student who fits either or both of the following. He must have an I. Q. between 75 and 90 verbal or he must be 2 years behind in achievement. The distinction is not made between students who have experienced early deprivation of physical or social experiences and those who are genetically limited.

Kidd, et al. (1970) have illustrated graphically that students who have difficulty learning mathematics cannot be made to fit easily any one category. They are defined in a variety of unflattering ways:

1. low achiever - those who achieve at 2 years below grade level in all subjects.
2. under-achiever - achievement in mathematics is 1½ - 2 years below other areas of study.

3. slow learners - I. Q. less than 90.

4. culturally disadvantaged.

It is suggested that a single category may overlap with one or more categories, providing many possible subgroups of students who are not working at grade level.

The above definitions generally underscore two specific groups with whom we are concerned in the classroom. One is the genetically deficient and the other is the student who has the native ability but who is not achieving at a level commensurate with his classmates. The amount of overlap is considerable but in grouping practices at the junior high level it can be assumed that the low achievement group is also that group which has the lowest I. Q.

Characteristics

Research has provided characterizations which describe the low achiever/slow learner. Beilin and Gotkin (1964) found the intellectual performance of the slum child to be comparable with that of a younger middle class child. In terms of Piagetian development, the slow learner is beset by language difficulties and a limited ability to conserve.

Kidd, *et al*. claim the student of good ability who is doing poorly in mathematics is generally an anxious child. Feldhausen and Klausmeier (Suydam, 1971) report that children of low I. Q. have a greater mean anxiety level than students of average ability.

Younie (1967) sees the low ability/achievement student as devalued by society. This label produces a bad self-concept and hence truancy, dropping-out, and delinquency.

Lovell (1961) has determined that the less able adolescent does not develop beyond the concrete operational stage and in this Lovell is reinforced by Inhelder (1958) who attributes slight backwardness to an inability to reason formally.

Sobel (1959) suggests that certain characteristics which apply to all adolescents become crucial when considering the implications for the education of the slow learner. The slow learner becomes obsessed with "getting the answer" and does not concern himself with whether the answer is right or wrong.

Younie (1967) has suggested that the student who achieves lowly in secondary mathematics is a low achiever in other subjects as well. The condition has become chronic by the junior high years.

The characteristics described above have serious implications for mathematics education and the student who achieves lowly in general.

A few words are in order concerning the factors which influenced the growth of those characteristics which distinguish the low achiever/slow learner. Leiderman (SMSG, 1964) is quite radical in his assumption that the cause of low I. Q. and retardation of achievement may be traced directly to a

deprivation of physical and social experiences earlier in life. He does not attribute low achievement to genetic deficiency. Piaget and Inhelder (1958) concur with the suggestion that growth of formal thinking is dependent more upon social factors than neurological. Piaget (1964) has further stated that intellectual development is dependent upon verbal interaction.

Correlations exist between student achievement and attitude. Students who do poorly in mathematics frequently have very negative feelings toward the subject. (Aiken, 1970) Husen (Aiken, 1970) found correlations between attitude of students and teacher understanding of mathematics. Generally, teachers who understood their subject had students with good attitudes.

Birr (1969) reports that the way parents view their children's ability has significant effects upon the students' self-concept and Younie (1967) reports that in defending against the devaluation by society the student creates more learning problems for himself. Kidd, *et al*. (1971) report that students of average or above average ability who are not achieving at grade level are frequently suffering anxiety associated with parental pressure to do well.

Instructional Guidelines

Certain guidelines have been established by researchers concerned with programs for the slow learner/low achievers. Focus has been somewhat varied in each case but there is nearly

unanimous agreement that the following be included in preparing a program:

1. evaluation should be in terms of individual growth.
2. good work should be exhibited.
3. students should not be chastised publicly.
4. homework should be very structured, short, related to previously learned material and turned in on time.
5. course prestige should be developed.
6. activities must be varied.
7. concrete presentations should be emphasized.
8. spiral development of topics and frequent reviews are necessary.
9. subject matter should be correlated with that in other courses.
10. practical application should be included.
11. drill is essential.
12. verbal material should be developed orally.
13. projects should be short with a goal in sight.
14. instructions must be specific.
15. quizzes should occur frequently.
16. students should not be required to verbalize a concept.
17. laboratory settings are essential.
18. units should begin with new and significant subject matter.
19. routines should be established and followed.

Willis (Woodby, 1965, p. 17) stresses the need for

diagnosis by a teacher who is capable of recognizing the operational level at which the student is learning. The teacher must be able to function within the student's frame of reference (Woodby, 1965, p. 23) and where this is concrete operational in nature must be able to introduce materials appropriate to the existing structure. Beilin (1964) recognizes a need for materials which will facilitate transition to the formal operational level in experientially impoverished students. The mechanisms are obscure but possibilities do exist. Students must be provided with concrete materials and relationships established between the perception and the language equivalent. The transition from concrete materials to symbolic representations of a related idea must be done in an orderly and logical manner. The student will not be capable of formal thought until an association has been established between language (symbol) and concrete material.

IV. CURRENT DEVELOPMENTS AND RESEARCH

Research has been carried out with low achievers and slow learners in a variety of settings at the secondary level. Generally, research has been done in the classroom with the regularly scheduled class, either streamed or heterogeneously grouped. Some of the findings may be classified under instructional method or learning characteristics. Students who have a history of failure in mathematics are generally

behind their fellow students in terms of arithmetic skills. Research with students in remedial classes has been fairly common and some of the findings are reported here. DeVenney (SMSG, 1964) reported that students, who were behind grade level in mathematics only, benefitted from extensive in-class use of data tables and note taking reviews. The students observed were working at grade level after one year remediation.

Younie (1967) has urged that programmed instruction should not be relied on nor any totally visual representation. He stresses that manipulative devices and activity lessons are essential elements for slow learners.

Recognition of the need for manipulative devices is apparent in the research done with laboratory presentations. This research has been categorized (Kieren & Vance, 1971) as follows:

1. as separate from the regular program
2. as integrated into the regular program.

Separate laboratories are those which have no apparent bearing on the topic being developed during the regular class time. Integrated laboratories are those which are concerned with the same content currently being taken in the regular classroom. In neither case has an attempt been made to develop the content in a strictly hierarchical manner, or in what Bruner would consider to be the natural sequence. Vance (1969) in separating the laboratory from the regular learning situation found no significant differences for the low achiever at the

junior high level in terms of achievement. He found that the students enjoyed the laboratory experience. Wasylyk (paper in progress) found that low achievers at the grade 9 level did significantly better in terms of achievement when exposed to integrated laboratories and found that attitudes improved significantly.

With respect to the multi-embodiment approach suggested by Dienes, Biggs (1965) has reported that the low achiever benefitted significantly. Dienes (1963) has reported that the inability of slow learners to abstract readily makes the multiple-embodiment representations a necessity for those students.

The organization of students in classes has been under consideration by many researchers. The most common grouping practice seems to be that of placing students in a class on the basis of his past record of achievement. Thus we are confronted with an entire class of slow learners and low achievers. Potter (1958) sees this grouping as essential to dealing with the differing abilities effectively. Younie (1967) sees grouping according to ability and achievement effective only if the selection is limited. Too often the "Basic" classes become a dumping ground for misfits of all kinds. These classes are no more homogeneous in ability than one class with a wide range of student achievement. Gerardi (Woodby, 1965) claims that students who are grouped according to ability learn more and enjoy more but LaBenne and Greene (1969) claim such labelling

can be very damaging to the self-concept. Beilin and Gotkin (1964) stress a need for suitable techniques after the grouping is established and Sobel (1959) and Younie (1967) stipulate need for an entirely new method of instruction after diagnosis of the problem. With respect to flexible grouping Sunde (1970) has reported that students who are regrouped with the introduction of each new topic take advantage of the mobility and do not remain permanently in one achievement level group. Sobel (1965) reported a need for small remedial groups with allowance for transfer to the regular classroom. Remedial classes must be instructed by teachers with a positive attitude toward the low achiever.

V. A POSSIBLE PLAN

The previous sections of this chapter have been provided as a foundation and rationale for the instructional program and devices outlined below. A cycle of conceptual presentation has been developed for the low achiever/slow learner which will be implemented and refined as determined by student response to the various alternatives offered. Criteria for selection and evaluation will be discussed in Chapter III.

A presentation of mathematical ideas to low achiever/slow learners should begin with new and interesting materials. The students under consideration dislike mathematics and

generally are alienated by repetition of those topics which have ended in failure in past years. (Potter and Mallory, 1958, p. 25) For this reason it is proposed that topics be chosen for their unfamiliarity to the students and remedial work be undertaken only when necessary for skills necessary to the acquisition of new concepts. Success with the new concepts can be achieved at the appropriate developmental level and therefore each new topic should be introduced concretely and transition made to symbolic only when the student exhibits an understanding through original application of the idea. Although transition to symbolic material will be attempted with every concept, it will not be viewed as the necessary achievement for mastery. Understanding as witnessed by meaningful manipulations of physical embodiments will be primary in importance. It is believed that many of these students are at a stage of development where transition from concrete operational to symbolic thought can be facilitated by proper sequencing of representational modes.

Each concept should be introduced as a laboratory type of experience where students are provided with physical embodiments which they will be asked to describe and manipulate. They will be encouraged to discuss relationships with other students and systematic questions will be provided which will lead the students to the desired associations. Students will be free to "play" with the materials but they will be expected to follow a highly directed question and answer pattern before continuing on to the following activity. Where elementary

concepts have been provided physically, students may have a choice of further, more complex developments through a build-up of physical embodiments or through the use of their own mental images of the simpler component structures. Each student will be encouraged to respond to written questions only when he is satisfied the answers are correct.

Symbols will be introduced only as they are needed for discussion among students. To delete symbols of a conventional nature in favor of funny names or some other device would be undesirable even though structurally sound. The students will be continuing on in the regular mathematics class upon completion of work with the research topics and the conventional symbol will provide a satisfactory means for communication of their newly acquired ideas.

In outlining an instructional method for the low achiever/slow learner certain factors do not appear to have a clear logic of inclusion into the instructional program. These factors are ones with which the study will be concerned. The teacher traditionally lectures or reviews important aspects of a concept but we do not know whether this exposition is best done prior to manipulation by students or following manipulation of physical materials. Scandura (1968), in discussing rule application has suggested that when specific rule responses are known in advance, the discovery of a general rule may be inhibited. Glaser (1968, p. 28) has stated that whereas school instruction has traditionally been deductive in nature, that is

the rule is stated first and then illustrations provided, research has been almost exclusively designed to study inductive behavior. He goes on to discuss the need for researching the efficiency and advisability of teaching certain concepts by the deductive or inductive method. A study of the effects of various locations of teacher explanation/demonstration in the sequence of instruction will provide some insight into a most desirable alternative for low achievers, if in fact one exists. Secondly, the effect of daily mastery of concepts and activities as determined by responses on exercise sheets related to activities can be compared on achievement tests to provide clues as to the necessity for competence on simple tasks before continuation with more complex. Finally, it is advisable to determine what types of materials students respond most favorably to as learning devices. It has been suggested that students need meaningful activities and yet they often do not respond well to social applications of mathematics. A study will be included to determine possible preferences for real life applications as opposed to those having a purely laboratory-mathematical orientation.

CHAPTER III

DESIGN OF THE STUDY

I. INTRODUCTION

Assuming a best approach to instructing the slow learner in the junior high school does exist, the course of this research project was directed toward establishment of those principles which would most effectively define that approach. The project was designed to provide evidence for incorporating certain variables into the theoretical program described in Chapter II. This evidence, provided by two groups of slow learners, consists of performance scores on achievement tests and statements of personal preference. Modifications were made on the proposed theoretical framework in light of the project results. This chapter contains a description of the experimental design and includes procedures for collecting data of a cognitive and clinical nature. Here clinical means investigation by observation of student response as distinct from controlled experiment. From these data an attempt has been made to identify relationships between certain slow learner characteristics and student progress.

II. THE SAMPLE

Setting

An attempt was made to find a school having at least one class of students at the junior high level whose learning characteristics were those of the slow learner. The school used for this study was located in a Portugese speaking community in Edmonton.

Existing Program

The students had been part of special sections of the regular school program and took most classes as a group. Their regular mathematics class met each day for 37 minutes with the major emphasis on textbook treatment. An expository method was used by the teacher and exercises assigned. In addition to the Foley Series (Foley, 1970), the grade 7 students were given lessons from a textbook (Eicholz, 1965) every Friday. The Friday mathematics exercises were primarily aimed at remediation and focussed on operations with the rational numbers.

Grade Level

The sample consisted of one special section of grade 7 students and five students from a special section grade 8 class. The five grade 8 students were selected in order to increase the

sample size.

Student Characteristics

The sample consisted of sixteen girls and eleven boys ranging in age from thirteen to seventeen years. I. Q. scores ranged from 56 to 101. For experimental purposes the sample was divided into two groups, the mean age and I. Q. of which are given in Table 3.1.

TABLE 3.1

MEAN I. Q. SCORES AND AGE OF STUDENTS IN THE TWO GROUPS

	Group I	Group II
N	12	15
I. Q.	85	84*
Age	14 years, 8 months	14 years, 5 months

*I. Q. scores for the three non-English speaking students were not available. 84 is the mean I. Q. score for the 12 English speaking students in Group II.

III. TREATMENT

Choice of Unit Topics

Content for the project was chosen on the basis of uniqueness, simplicity (few entering skills necessary) and relevance to future mathematics study. Plane geometry was chosen for the first two stages of the project. This topic requires sophisticated tools and language which provide a fairly high degree of status to the student. Signed numbers and metric geometry were selected for the final stage of the project. The three topics were entirely new to most of the students although a few had been introduced to them during an option class at a previous time. None of the students were able to give satisfactory responses to the most elementary questions concerning the various concepts. For example, although a few students claimed to have used the protractor in the past, none knew what was being measured or how the protractor was to be manipulated.

Choice of Lessons and Materials

Prior to the project students from the sample has been working from the Foley Series during the week with Friday set aside to do exercises from a textbook. The Foley Series is designed for the slow learner and the researcher decided to follow the content form for the plane geometry and sections

of the metric geometry booklets. All lessons were developed by the researcher following the Foley content outline and including appropriate activities with question sheets designed for each lesson. (see Appendix A)

An attempt was made to include one major idea in each lesson and the lesson was presented in its entirety each session. In most instances an idea was presented on two different (consecutive) occasions in two distinct forms. Where the introduction of an idea was restricted to physical materials and constructions, instructions were verbal and materials were accompanied by exercise sheets requiring descriptions of what the students were doing. All instructions and questions on the exercise sheets were verbalized by the teacher and students were encouraged to discuss their meaning while manipulating the materials.

Organization for Instruction

Each student from the sample was assigned to one of two groups with two restrictions on the placement. The five grade 8 students were placed in one group. A certain stigma, attached to being integrated with grade 7 students, was alleviated in this way. Placement was accomplished so that mean ability, as determined by I. Q. scores, were similar for the two groups. (See Table 3.1)

The two groups met in different classrooms during the

regularly scheduled grade 7 mathematics class time. The regular grade 7 teacher instructed the group comprising all grade 7 students and the researcher instructed the group comprising grade 8 and grade 7 students. The grade 8 students were receiving instruction in mathematics during a regularly scheduled class three additional periods a week. There was no overlap in content with the experimental program. The classes met for 37 minutes a day, five days a week.

Procedure

The program model was implemented according to the rationale set forth in Chapter II. Students were exposed to concepts embodied in physical materials before being introduced to symbolic representations. Work sheets accompanied every activity and each lesson concluded with exercises relating ideas from the activity to new situations. The program was modified with respect to three variables. The variables were studied singly as they effected each of the groups in similar learning situations. The three variables studied were:

Teacher demonstration: This referred to the lecture and explanation of a concept given by the teacher. An attempt was made to determine whether this action should occur before students were involved in the activities concerning the concept to be learned or after the activities. In most instances the demonstration consisted of an explanation of the idea, including its relationship to the physical activity accompanying the lesson.

It was more than a set of rules for manipulating physical materials but generally included such an explanation.

Mastery: The degree to which a group of students completes a lesson and how this effects long term scores. In one group most of the students learned each lesson with at least 80% correct on each lesson exercise before proceeding. In the other group students proceeded through scheduled lessons disregarding the level of attainment of the students. The group learning for mastery each day was to be assessed at the end of each lesson and either the concepts would be reviewed until mastery was achieved or, if the degree of mastery had been attained, the group was permitted to go on to the next lesson. At the end of a two week period both groups were given an exercise test covering the material presented to the non-mastery group over the two week period.

Socially relevant vs. laboratory related conceptual development: The final lessons were presented in one or two ways. The concepts were presented in a setting which was meaningful in terms of the student's daily lives and again in a setting which was based on mathematical structure but without particular significance in terms of past student experience. (see Appendix A) Both interpretations were alternately presented to the two groups on two different concepts.

Chronological organization of the study

Phase I: Group I was instructed for one week with teacher

explanation/demonstration following lesson activities. Group II was instructed using the same lessons but teacher demonstration was given prior to the activities. The following week the groups were switched with respect to the teacher demonstration factor and an achievement test was administered at the end of the two week period.

Phase II: Group I was instructed as in previous lessons, using teacher demonstration last, and seven lessons were introduced on seven consecutive days. Group II began with the same lessons as Group I but the students were evaluated each day by the group teacher and a decision was made as to whether the group had mastered the concepts involved in each lesson. In those lessons where mastery had not taken place (see definition Chapter I) the lesson was reviewed on the following day. At the end of the seven day period the Group II students had not covered as many lessons as Group I. An achievement test was administered on the day following the seventh lesson.

Phase III: During the final series of lessons Group I was instructed for two lessons using socially meaningful activities whereas Group II received instruction of a laboratory, but not particularly real-life related nature. Those lessons were followed by two more lessons, introducing a totally unrelated topic (operations on signed numbers). The groups were switched so Group II received the socially meaningful treatment and Group I received the lessons in a setting which did not relate to their daily lives. An achievement test was administered following the

two sets of lessons.

IV. CONTROLS

Teacher Orientation

Each group was instructed by one teacher. The regular grade 7 teacher was a reading specialist with a major in Elementary Education and B.Ed. degree from the University of Alberta. Her training had included a half year course in Mathematics Curriculum and Instruction at the elementary level. She was completing her first full year of teaching at the time the project was carried out.

The researcher had taught junior high mathematics for one year full time and two years on a part time basis. This included classes of slow learners. Training included a B.Ed. in Secondary Education and the related Mathematics Curriculum and Instruction courses as well as pure mathematics courses.

The teacher who participated in the study was given an interview one month prior to the actual implementation of the project. The purpose and content were discussed at that time and grouping priorities outlined. A decision was made to present a week of lessons to the teacher one day in advance. Each lesson would be presented to the teacher by the researcher, and any problems could be resolved before implementation. Areas in which the teacher felt weak (in terms of mathematical content) could be reviewed at that time.

During these sessions it was also agreed to discuss previous lessons, focussing on student responses to both the over-all unit content and specific lessons. The teacher agreed to keep a diary in which she would indicate feelings toward the individual lessons and opinions concerning appropriateness, enjoyment for students and teacher, and efficiency in getting concepts across. Any irregular occurrences which might effect the success of a lesson or series of lessons were also to be noted.

Student Orientation

A primary consideration in planning lessons for the students was the low reading level and an inability to associate symbols with ideas. An attempt was made to keep all written instruction at a minimum and to simplify vocabulary. A further precaution was in-the-class discussion of all written material to be used during the lesson.

An introductory statement was made to the students one week before the study began. At this time students were told an experiment would be conducted which might provide information on how to teach mathematics so it would be both enjoyable and efficient. The students were told that they would be in the position of "evaluators" and as such would be expected to report those aspects of the daily lessons which did or did not appeal to them. A stress was laid on explanations and reasons for liking or disliking parts of lessons. An attempt was made to

convince the students that their comments were needed in order that any defects in the lessons might be corrected for future use.

Students were informed that the project would replace the regular mathematics class for a six or seven week period and that test scores would not be used on report cards. Exercise sheets were described and, along with exercise tests at the end of each unit, it was explained that performance on these exercises would provide another means by which the researcher might decide which lessons were successful and which were not. The responsibility for failure was placed on the materials and the researcher and responsibility for evaluation rested with the students.

The students were advised of the need for students from both grade 7 and grade 8 to participate in this study and were assured that comparisons between grade 7 and grade 8 students would not be made.

V. ANTICIPATED EFFECTS

Cognitive Aspect

In view of the literature review and related research findings discussed in Chapter II it did not seem reasonable to predict treatment outcomes of a particular type. The cognitive variables were chosen because they were particularly relevant to the instructional program yet at the same time had been

neglected in terms of empirically designed research. Instead of a statement of hypotheses this Pilot Study was concerned with a series of questions designed to provide possible direction for further research. The questions underlying the cognitive aspect of the study were:

1. Does student performance on achievement tests relate to the position of teacher explanation/demonstration in the instructional sequence? Is there an optimal position in the sequence?

2. Do differences exist between scores made by students who have mastered a concept and those who have not, but have covered more concepts? What is the nature of such differences and how might they influence classroom instruction?

3. Do differences exist between scores for students who study concepts in a socially relevant embodiment and students exposed to other embodiments?

In terms of the theoretical basis for the program, it was hoped to determine whether consistent incorporation of physical materials and grouping measures were indeed desirable?

Clinical Aspect

A second aspect to be studied was the relationship between student characteristics and classroom performance. In terms of the cognitive variables students were expected to provide feedback indicating preference of treatment. The main purpose,

however, was to determine those factors which most strongly influenced progress in the learning situation. Of the slow learner characteristics reviewed in Chapter II, which ones seemed most influential to the daily lessons and progress in general? A relationship between student attributes and academic progress was being sought in order that the most significant could be isolated.

VI. DATA COLLECTING ACTIVITIES AND INSTRUMENTS

Cognitive

Performance scores on tests related to treatment segments provided criteria for evaluation of effects of particular variables on instruction. Daily exercises provided feedback indicating the value of a lesson in conveying the concept to be learned. Insufficient student response on a single lesson indicated personal failure to understand written instruction possibly attributable to conceptual development.

The second phase of the study relied heavily upon daily exercises, for Group II, as a measure of mastery. Once again the exercise test also influenced evaluation of the variable being studied. Achievement tests were constructed on the unit objectives. Essentially, one question for each objective was included with stress upon the application of concepts.

It was hoped that perusal of daily exercises might provide some indication of whether transition from activity

centered learning to symbolic had taken place. This knowledge might not help predict group performance on achievement tests but could provide a rationale for deleting symbolic presentations until a later time.

Clinical

To gain insight into effectiveness of the materials used, students were asked to keep a diary, recording their feelings about lessons they had each day. They were asked to describe aspects that they did or did not enjoy and include explanations and suggestions for improvement. At the end of the first phase students were interviewed individually by the researcher and an attempt was made to gather data concerning lessons which students had particularly enjoyed and those perceived to be mose meaningful. During the interview students were asked to compare the project lessons with the mathematics lessons they had engaged in during the school year prior to the project. Specifically, they were asked to compare content, activities and exercises with respect to enjoyment, relevance to themselves, and comprehensibility of concepts.

The regular teacher had agreed to keep a diary indicating her impressions of various lessons, how well students responded to individual lessons, and insights into the over-all success or failure of a given lesson. She was asked to study the feasibility of implementing these kinds of lessons into the regular mathematics program on a full-time basis. The focus

here was on preparation time, need for classroom tools and set-up time, and extra time for correcting exercises. The teacher commentary was modified to exclude the written diary after the first phase of the project due to the time factor. Instead, verbal feedback was given the researcher at the end of each unit and occasional notes attached to the daily lessons.

The various aspects studied during this project have been listed in Table 3.2 with data collecting activities associated with each.

VII. EVALUATION PROCEDURE

Due to the nature of the sample and purpose of the study, a rigorous statistical analysis of data was not advisable or possible. A successful interpretation of clinical data depended upon the collection of original responses from students. The study was designed with the enough flexibility to permit the students to indicate those factors which influenced their behavior most significantly. Analysis of clinical data depended upon continuity of responses among students and the chronology of responses as they related to the lesson sequence.

Data collected on the cognitive variables were analyzed and a decision reached as to which treatment merited further study or inclusion in the instructional program.

In terms of cognitive measures, the performance of students on achievement tests was recorded and comparisons were done for between and within group differences with respect to each

TABLE 3.2

DATA COLLECTING TOOLS AND ACTIVITIES ASSOCIATED WITH EACH ASPECT OF THE STUDY

		data gathering activities and tools			
		student diaries	personal interview with students	teacher reported observation	achievement test scores
Aspects studied: Chronological inclusion in the project	Teacher explanation/ demonstration (Phase I)	✓	✓	✓	✓
	Daily Mastery (Phase II)	✓		✓	✓
	Social Relevance (Phase III)	✓		✓	✓
	physical activities (duration of study)	✓	✓	✓	
	grouping procedures (duration of study)	✓	✓	✓	
	extra-instructional factors (duration of study)	✓		✓	

variable. Partially, the success or failure of a variable was determined by the scores of the two groups under the influence of the particular treatment. Cognitive data was studied in conjunction with attendant clinical data and results of the treatments were dependent upon both aspects of the study. For example, where two treatments seemed to be equally effective in terms of achievement scores, student attitude suggested one treatment as preferred. Conclusions based on an analysis must be carefully considered in this context and future research rigorously controlled to ascertain possible cause and effect relationships.

CHAPTER IV

A DESCRIPTION AND ANALYSIS OF BEHAVIORS ASSOCIATED WITH THREE INSTRUCTIONAL VARIABLES

I. INTRODUCTION

This chapter provides a description of the classroom behavior resulting from introduction of instructional variants outlined in Chapter III: teacher demonstration, daily mastery of lessons, and the socially relevant lesson. Data on each variable were studied and analyzed from three different viewpoints. First, the student diaries were scanned for items which directly reflected personal views of the variables. Did the students feel that the alternative presentations were affecting enjoyment or learning? On direct questioning to determine preferred lessons, did student response indicate preference for lessons given in a particular manner? If so, which treatment of the variable under consideration was preferred?

Secondly, teacher observations are discussed. An attempt has been made to determine which lessons were most successful (as perceived by the teacher) and whether this was influenced by the variable in question. The teacher record includes both a description of classroom climate and personal preference for alternate variable treatments.

Finally, a section is devoted to the actual scores on achievement tests administered after each variable treatment. The groups have been studied for within and between group differences without assuming they are samples from the same population. Factors such as absenteeism and language difficulty varied greatly between groups.

The three criterion effects were studied together and conclusions drawn regarding the best treatment for each variable studied. Where conclusions were based upon one of the criteria, reasons were given for the seemingly biased evaluation. Conclusions were determined as a direction for further research with the variables. As such, they provide a basis for future hypotheses.

II. TEACHER DEMONSTRATION

The first two weeks of the project were devoted to the position of teacher demonstration in the sequence of each lesson.

Week 1: Group I was given the teacher explanation/demonstration following lesson activities and group II was given the teacher explanation/demonstration prior to lesson activities.

Week 2: The arrangement was reversed and group I had demonstration first while group II had demonstration last. Lesson content was identical for both groups as were activities, exercises and achievement tests at the end of each week. (See Appendix)

<u>Student response to sequence position</u>

Very little evidence was found in diaries to support either position of teacher explanation/demonstration in the sequence. Those responses which reflected a preference for one or the other treatment were given entirely by group I students along with reasons for the preference. The following excerpts were taken from student diaries.

> Student A: I think that I can learn better. . . . (activities first) because when we're doing it we are the ones to set it up and if they are on the board we don't learn much we just see.

> Student L: I prefer working with chalkboard last because teacher could correct your mistakes.

At the end of the two week period, students were shown materials from each lesson and asked to indicate:

1. which lesson they had enjoyed the most
2. which lessons they had learned most from.

Students were questioned individually. Results of the two questions are indicated in Tables 4.1 and 4.2.

How students perceived individual lessons appears to be independent of the position of teacher explanation/demonstration in the sequence. Rather, enjoyment seems to be dependent upon certain lessons. For example, lessons No. 5 and No. 11 were not enjoyed most by any student whereas lessons No. 4 and No. 6 were enjoyed most by some students from both groups. Students did not seem to perceive enjoyment to be associated with greatest

TABLE 4.1

LESSONS STUDENTS ENJOYED MOST

	Lesson number							
Group	4	5	6	7	8	9	10	11
I	111		111			11111	1	
II	11		11	11	11	1	11	

TABLE 4.2

LESSONS STUDENTS BELIEVED THEY LEARNED MOST FROM

	Lesson number							
Group	4	5	6	7	8	9	10	11
I		11	11		11	11	1	111
II	11		11	1	1	1	1	1111

learning. The greatest number of students from both groups chose lesson No. 11 as that from which most was learned yet none chose that lesson as most enjoyable.

Teacher response to sequence position

The teacher of group I, researcher and author of this report, observed two functions for teacher demonstration. The nature of the two functions prohibited conclusions on both. As illustration, lessons No. 9, 6, 4, have been chosen for reference. From Table 4.1, 4.2, it is apparent that group I enjoyed lesson No. 9 to a very great extent. Furthermore, this teacher claims lesson No. 9 was in fact the single most satisfying in that particular phase of the project. During that lesson, students worked with essentially no extra-curricular conversation and, for the most part, independently of one another. To the observer, the class was engrossed individually in the lesson activity. (see Appendix A) In fact, the Vice-Principal of the school walked through the classroom and went unobserved by all but one student, such was the concentration level. The particular lesson had been introduced by the teacher and a step-by-step illustration of the lesson activity had been presented. The major concept--the sum of angle measures of a triangle equals 180°--was verbalized and demonstrated prior to class activity. The actual activity of coloring, tearing off "angles" and pasting together to form a straight "angle" was

thoroughly understood by the students in group I. The particular activity of lesson No. 9 required a good deal of direction for results (the actual formation of a model for a straight angle) to be accurate. It would appear that for group I this lesson was a success and teacher demonstration had been givenprior to student activity.

Referring now to lessons No. 4 and No. 6, selected by a significant proportion of group I students as most enjoyable, both lessons entailed working with cardboard segments, angles, and protractor with very simple and concise instructions given on the activity sheets. Demonstration by the teacher followed the lesson and both lessons went smoothly. The point is, students understood exactly what to do during the lesson activities.

Group II exhibited very little strong group preference for a single lesson although lessons No. 4 and 6 received two votes each while No. 9 received one. It is to be remembered that group I was receiving demonstration by teacher first for lessons No. 4 and 6 but demonstration last for No. 9. The group II teacher reported that students were very attentive during the pre-lesson demonstrations but asked very few or no questions. Questions which were asked generally referred to instructions concerning lesson activities to follow. When the teacher demonstration for group II was sequenced to follow the lesson activity, as it did in lesson No. 9, students seemed restless, frustrated and had many questions to ask concerning

the demonstration. It was not until the lesson was finished that most students realized what they were actually supposed to do with the materials. Both teachers noticed that when demonstration was first, students watched the screen, blackboard or other model but rarely asked questions. When demonstration was given last, both groups were generating questions which indicated a need for concept clarification.

The foregoing discussion has been interpreted to imply a dual function of teacher explanation/demonstration:

1. explanation of the step-by-step process to be followed in carrying out an activity or activities.
2. statement of the concept or relationships of an abstract nature.

Communication from the two teachers concerning student response under the two variable treatments suggest two trends. First, students must have clear understanding of their role in performing lesson activities. They must know why certain manipulations are being performed but not necessarily what the final result will be. Secondly, students will probably not benefit a great deal from a statement (or teacher demonstrated model) of abstract relationships unless the students have had the opportunity to view the basis of these relationships at a personal level.

Achievement scores measured over the two treatments

Achievement tests were administered at the end of each week in a form similar to that of daily exercise sheets. (see Appendix

B) Individual student scores are also listed in the Appendix. Group means, standard deviation and variation are listed in Tables 4.3 and 4.4.

A study of scores at the end of the first week reveals group II has a mean of 63.6 while the group I mean is 61.5. The "demonstration first" group is very slightly superior. Scores at the end of the second week indicate the group I mean is 57.5 while the group II mean is 69.3. Scores are decidedly superior for the "demonstration last" group. Viewing the groups individually, one observes that group I had a mean score of 57.5 when demonstration was first and 61.5 when demonstration was last. Group II had a mean score of 63.6 when demonstration was first and 69.3 when demonstration was last.

A confounding factor appears when averaging achievement scores for group II. The group performance can be attributed to the scores achieved by the three non-English speaking students in the group. A breakdown of group II into English and non-English speaking subgroups is shown in Tables 4.5 and 4.6. Comparison of scores for the groups takes on a new perspective. Whereas group II seemed to score slightly higher than group I on both achievement tests, the teacher explanation/demonstration last treatment seemed to favor both groups. With the extraction of the non-English speaking subgroups, differences in means between the two original groups are not significantly different. The most striking effect is that on the scores of the non-English speaking students. The first week their mean score (under the

TABLE 4.3

MEAN ACHIEVEMENT SCORES UNDER THE TWO TEACHER EXPLANATION TREATMENTS FOR GROUP I

	N	M	SD	S^2
Week 1 demonstration last	12	61.5	21.6	469.3
Week 2 demonstration first	12	57.5	21.9	479.8

TABLE 4.4

MEAN ACHIEVEMENT SCORES UNDER THE TWO TEACHER EXPLANATION TREATMENTS FOR GROUP II

	N	M	SD	S^2
Week 1 demonstration first	15	63.6	17.6	310.1
Week 2 demonstration last	15	69.3	24.7	609.6

TABLE 4.5

MEAN ACHIEVEMENT SCORES UNDER THE TWO TREATMENTS

FOR THE ENGLISH SPEAKING SUBGROUP

	N	M	SD	S^2
Week 1	12	66.5	14.9	223.4
Week 2	12	64.6	25.1	631.3

TABLE 4.6

MEAN ACHIEVEMENT SCORES UNDER THE TWO TREATMENTS FOR

THE NON-ENGLISH SPEAKING SUBGROUP

	N	M	SD	S^2
Week 1	3	51.7	19.1	367
Week 2	3	88.3	8.1	65.7

teacher explanation/demonstration first treatment) was 51.7, lower than the group I mean by nearly 10%. On the second achievement test (when teacher explanation/demonstration was last), their mean score was 88.3%, higher than the group II mean by more than 23%.

III. DAILY MASTERY

This variable was treated in two ways:

1. Group II was responsible for completing the daily exercises with 80% correct for at least ten of the students.

2. Group I covered each lesson and continued on to the next without regard for degree of mastery.

Content for this phase of the project was a continuation of the first two weeks. (See Appendix A) The plan for group II was for a decision to be made by the teacher as to whether the group had mastered a particular lesson. If it was decided they had not, a review lesson was given which reviewed the basic concept at the next class meeting. It was expected that group II would have covered fewer lessons at the end of this phase of the project. An achievement test was administered following the seventh lesson. Group II had completed six of the seven lessons and group I had completed all seven.

Student response to the Mastery Lessons

The diaries revealed no specific comments concerning

mastery per se, but notes taken were relevant. Students for the first time indicated they were having difficulty with "understanding" the material and also indicated for the first time they found certain lessons "boring." Some comments from both groups are included in chronological order to give the reader an idea of the general feeling of that group.

Comments from Group II

May 10:	Student S:	Today's math was really great. I really enjoyed it.
	Student D:	Today's lesson was fun.
May 11:	Student M:	Today's lesson was a little bit hard but I think it was really enjoyable.
	Student D:	Today's lesson was sorta hard because it was new but I know all about concave and convex.
May 16:	Student S:	Today's math was kinda boring but the time went fast.
	Student M:	I really did enjoy math today but it is getting a little bit harder every day.

Comments from Group I

May 11:	Student J:	I hated today's lesson.
	Student P:	Measuring this work is a little hard for me, I don't understand it at all. That's why I don't like it.
May 12:	Student R:	I liked the lesson because that man (Dr. Kieren) helped us and he even gave us harder questions but they were easy to us.

The above sampling may be taken as an indication that students were feeling ill at ease with the lessons on many days. In one instance, a student indicated she knew all about concave and convex (the lesson concerned measurement of Reflex angles). A check of that achievement test item indicated she did not. However, a further check of that student's daily exercise indicates she did in fact satisfactorily complete the questions.

Teacher Response to the Mastery lessons

The group II teacher indicated the lessons in general gave the students more trouble than the previous phase of the project. Furthermore, assessing the student's daily mastery had proven difficult in view of student participation in group work. The teacher was unable to determine whether individual students had in fact done their own work and mastered the concepts independently. Exercise sheets reflected a high degree of mastery. The teacher decided to question students to satisfy herself they did indeed understand the material. Her decision was based on this oral questioning in addition to completed exercises.

The teacher of group I, the group following the pre-conceived lessons at a pre-planned rate, noted a general lack of understanding on many of the lessons. Students had a difficult time understanding questions on the exercises and frequently did not complete an activity independently. The

students also complained they were given more difficult lessons than the other group. The frustration level was quite high and absenteeism increased considerably. Of the seven lessons, three of the five grade 8 students were truant on four occasions.

Achievement scores

An achievement test was administered following the seven lessons. Both groups took the test, which covered material from all seven lessons, although group II had covered only six. A comparison was made of mean scores for the two groups and a tally was made of the number of students who received full credit on each test item. Items corresponded with individual lessons.

Table 4.7 shows the mean group scores and Table 4.8 is a tally of number of students responding correctly to each item. (A list of student scores on the achievement test are included in the Appendix.)

The group means were not very different, the mastery group showing 30.5 and group I showing 35.3. Consulting Table 4.8 however, one sees that item 7, that which tested the concept studied in the last lesson and which had been covered by group I only, did not serve to explain the difference in mean scores. Only one student answered the item correctly from group I and none from group II.

The items missed on the achievement test were similar

TABLE 4.7

MEAN ACHIEVEMENT SCORES OF BOTH GROUPS

AFTER THE MASTERY PHASE

	N	M	SD	S^2
Group I	12	35.3	18.2	331.7
Group II	13	30.5	19.9	397

TABLE 4.8

PERCENTAGE OF STUDENTS RECEIVING FULL CREDIT ON ITEMS

ON THE MASTERY ACHIEVEMENT TEST

Test Item	Number of Students who responded Correctly Group I	% of Students who responded Correctly Group I	Number of Students who responded Correctly Group II	% of Students who responded Correctly Group II
1	6	(.50)	6	(.46)
2	4	(.33)	7	(.54)
3	2	(.17)	4	(.31)
4	5	(.42)	1	(.08)
5	0	(0)	0	(0)
6	1	(.08)	1	(.08)
7	1	(.08)	0	(0)
	N = 12		N = 13	

for the two groups with differences occurring on item 2, which tested the only lesson repeated by group II, and items 3, 4, and 7. Items 2 and 3 show a significantly better performance by group II with 54% and 31% of the students responding correctly whereas group I had 33% and 17% responding correctly. Items 4 and 7 show group I superior with 42% and 8% responding correctly compared with 8% and 0% for group II.

It is apparent that success diminished for both groups as the series of lessons proceeded. Group II shows best results on the item which tested the only lesson which had been repeated and on the item immediately following. Group I is superior for item 4 at which point group II began to show a decline in performance.

IV. SOCIAL RELEVANCE VARIABLE

During this phase of the project, both groups were exposed to linear measure and operations with signed numbers. Linear measure was presented to group I as an application to things the students were familiar with. For example, they were asked to measure such items as pencils, ribbons, books, etc. Group II was given an academic context which consisted primarily of paper and cardboard models of geometric shapes. The context was switched for signed numbers and group II was presented a model with which they could easily identify. (see Appendix A) Group I used a game which was essentially a mathematical model with which none of the students were expected to identify.

Student responses to the two activity types

A perusal of the diaries reveals both groups had commented on the linear measure lessons. Group I, those who were using familiar objects, were split in attitude to the presentations. Of eleven students for group I who responded to the second lesson on linear measure, four liked the topic, four disliked the topic and three were neutral. Reasons for liking the lessons were primarily associated with being able to use a ruler. Students recognized the value of such an accomplishment. Reasons for disliking the lessons were almost unanimously boredom with the repetition of measuring.

Of seven from group II who responded to the lessons on linear measure, four made positive comments, one was negative and two were neutral. Again it was felt that skill in using the ruler was a good thing to have. Some students also felt using the ruler was fun. The negative comment was made by a student who claimed he did not like working with the ruler. (His teacher indicated he was unable to measure fractional parts).

The lessons on operating with signed numbers proved confusing to both groups. Group I had no diary entries but seven students responded to a question of preference on the achievement test. (see Appendix B) Of the seven, five claimed to have enjoyed the game, one response was negative based on the fact that the student never won a game, and one response was neutral. Group II diaries revealed six comments; three favorable,

two negative and one neutral. The favorable responses claimed the Postman Stories were fun, while the negative claimed the model was confusing. Eight students responded to the preference question on the achievement test. Three said they enjoyed the lessons and five said the lessons were too complicated or confusing.

Teacher response to the two activity types

The group I teacher had few observations regarding the linear measure lessons. Students generally did their work with some grumbling about too much repetition. Students as a whole seemed to be confident they had mastered linear measure and were not favorably disposed to practising with the ruler. Measurement of such ordinary items as one's notebook seemed to interest students initially but the novelty soon wore off. Students did not really seem to care how long a pencil might be in inches.

The group II teacher reported a similar class reaction to practise with the ruler. Students found learning to use the ruler a valuable endeavor, but repetition of measurement exercises bored them.

The lessons involving operations with signed numbers proved very eventful for both teachers. The group I teacher reported high excitement over playing a game instead of having a regular lesson. The rules of the game were carefully explained but students often failed to abide by them--using rules which were

often easier to apply but caused a breakdown in the structural model necessary for the desired operations. Also, it was observed that certain students who understood the game would deliberately mislead opponents in showing them how to score! The competitive spirit was so keen that students disregarded much of the structured playing and scoring necessary for building a model with which to associate the signed number operations.

The teacher for group II reported a very different problem in her group. Students seemed anxious to participate in the Postman deliveries and responded correctly to delivery of mail but were unable to correctly symbolize the deliveries in mathematical notation. It was discovered after the lessons had been presented that a large portion of the solutions (about 1/3) on the teacher's answer sheets had been incorrect. It is supposed that students were unable to correct their exercises properly and thus a plausible explanation for their confessed "confusion". One can only presume the degree to which the incorrect assessments affected subsequent performance on the achievement test.

Achievement Scores for the Lessons

Scores for individual students are recorded in the Appendix. Table 4.9 and Table 4.10 show the group means and standard deviation for the two types of lessons.

As can be seen from the tables, group means are very close for the two groups in linear measure. The difference is

TABLE 4.9

MEAN ACHIEVEMENT SCORES ON BOTH TOPICS

FOR GROUP I

Lessons	N	M	SD	S^2
linear* measure	9	63.3	14.6	213.1
signed number operation	9	41.6	24.8	497.5

*Those lessons taught in the socially relevant setting.

TABLE 4.10

MEAN ACHIEVEMENT SCORES ON BOTH TOPICS

FOR GROUP II

Lessons	N	M	SD	S^2
linear measure	13	64.9	19.9	396.7
operations* signed numbers	13	35.1	21.6	468.2

*Those lessons taught in the socially relevant setting.

more striking for operations with signed numbers.

Summary of Findings

An attempt has been made to determine a basis for the incorporation of three variables into a particular instructional program. The three variables were:

1. Teacher explanation/demonstration
2. Mastery of daily lessons
3. Socially relevant activities.

Teacher explanation/demonstration was found to have a dual function. It served as a set of directions which indicated how students were to proceed and what questions were to be answered by an activity. A second function was that of a statement of relationships of an abstract nature. As a set of directions and questions, teacher explanation was best provided prior to the lesson. As a statement of relationships, the explanation was best given following lesson activities.

Findings during the mastery phase showed no significant differences in achievement scores between students who had covered all seven lessons and those who had covered only six. A difference was observed in the number of students responding correctly to the lesson reviewed by the mastery group.

The social relevance context provided students with a familiar model from which to abstract ideas. Students in the socially relevant setting were aware of structural limitations whereas the students in a purely laboratory setting were not.

CHAPTER V

STUDENT - TEACHER RESPONSE TO CERTAIN ASPECTS OF THE INSTRUCTIONAL PROGRAM

I. INTRODUCTION

The instructional program was formulated on certain assumptions. In this chapter an attempt is made to validate those assumptions in terms of student and teacher response. This chapter also includes a record of clinical data bearing on student performance. The three areas discussed in detail are:

1. physical activities -- an assumption was made that physical activities are a necessary part of concept development for the students under study. Did evidence support this assumption?

2. grouping -- it was assumed that permitting students to discuss the lesson activities and help one another find answers would have a positive effect on learning. Did evidence support this assumption?

3. extra-instructional factors -- did available data suggest that extra-instructional factors were influencing student performance in the classroom? What was the nature of the influence?

Student and teacher responses were derived from diaries and personal interview data.

II. RESPONSE TO PHYSICAL ACTIVITIES

During personal interviews with individual students the researcher asked each student two questions:

1. What did you like or dislike about the materials used during daily lessons?

2. How would you feel about continuing this approach with other math topics?

Students were questioned individually and had no opportunity to discuss their answers with one another before the interview.

Reasons for liking activities, given by students were of two types:

1. Students would rather do the activities themselves, not just listen to the teacher.

2. It is easier to get the answer to questions on exercise sheets since the student can see what happens.

Included are a representative sample of responses from students of both groups:

Student C: The objects helped get the right answers to questions on exercises. In some cases it is just as easy to look at pictures.

Student V: Using materials makes it easier to understand and get the answers right. I don't want to go back to the old way of doing math. You don't have to waste time getting answers (this way). I would not like another topic.

Student A: You label the objects yourself and you learn more. With pictures you just see the labels.

Student R: I would not like to go back to the textbook because I get more out of using the things. I always understand with the objects. You can check your answers by using the angles you have in your hand.

Student C: I like geometry and would like it out of a textbook. I would not like to go back to the old math. Would like any topic using objects.

The overwhelming majority felt the objects and activities were easy to use and made questions easier to answer. More importantly, the students found the activities enjoyable and preferred lessons with them. Interestingly, students generally did not believe it would be possible to use physical objects in lessons other than geometry topics. They believed they enjoyed geometry and would like it even in a textbook. Fractions, generally used synonomously with "the old math," were thought to be dull no matter how they were approached. In the minds of the students the activity centered lessons were inextricably tied in with geometry (and presumably operations with integers). They did not wish to return to the "old math" (that which they were doing prior to the project) because it meant fractions. In general, they thought they would not like fractions even if it meant using physical objects to learn about them.

The teacher response to the activity centered lessons was equally positive. The researcher, who developed all lessons, was reinforced in her belief that students were enjoying the activities to a high degree. It was clear that students retained images of physical activities and models from one lesson to

another. Questions were answered by students who referred to their mental images of these past activities.

The teacher for group II, a volunteer for the study, indicated her belief that students were enjoying and learning more than with the textbook approach. She had one overwhelming objection to the lesson activities and this was the amount of time and labor it involved for her. Even though all materials and lessons were prepared in advance by the researcher, the group II teacher found implementation both mentally and physically exhausting. It is to be remembered that this teacher did not have expertise in the field of mathematics and each lesson required more preparation than would a textbook presentation.

III. RESPONSE TO GROUPING

Slow learners generally have little perseverance and need structured lessons with simple directions. It is theoretically desirable to encourage students to verbalize concepts and yet in practice these students often seem to abuse the "privilege" of working in groups. It was therefore thought desirable to study the response to group work; both how students felt about working in groups and how the teachers reacted to the grouping.

Student comments in the diaries were generally very favorable to working with other students. In certain cases single students indicated they would rather work with a partner

other than the one they had been assigned or even a partner from the other group. Usually, students were permitted to pair up by choice and the reaction was that of enjoyment. It was not unusual for a student to claim he/she enjoyed the class because he was working with a friend:

> Student S: Today the lesson was interesting.
> It was nice to have Debbie back and
> I enjoy working with her.

In groups where students were not "best friends" there was a reluctance at first to share knowledge. Some students would work independently, covering answers on exercise sheets, and refused to discuss the meaning of activities to others in the group. One can only assume this is a habit formed through years of being told to "do your own work."

The teacher for group II was reluctant to permit group work for fear discipline problems would arise. Students were told they would be permitted to pair up only if noise was kept down and discussions involved material in the lessons. The group I teacher observed students worked well in groups with a need for occasional reminders that topics of conversation should be confined to the lesson activities. Initially, students seemed quite reluctant to share information. They were also reluctant to discuss the activities within earshot of the teacher. This situation gradually changed so by the end of the project ideas were flowing freely. Students still needed reminders to confine conversation to math topics but the teacher did not feel this problem was great enough to justify

restricting students to silence and independent study.

IV. EXTRA-INSTRUCTIONAL FACTORS EFFECTING CLASSROOM PERFORMANCE

Response to the grading procedure

Originally, students from both groups had been informed by the research that marks from the achievement tests would not be recorded on report cards. They were given to understand that for the duration of the project their test marks would be used as an indication of the success or failure of the experimental method and as feedback to the researcher indicating need for modifications. The regular teacher had agreed to record report card marks based only on student cooperation during the project. Students had been very enthusiastic about the prospect of such a grading system.

The first two weeks of the project went fairly smoothly in terms of marking with essentially no response in the diaries to testing of marks. In fact, students seemed to think of the project as pitting one group against the other and were highly competitive about group averages but unconcerned (or so it seemed to the teachers) about individual marks. This very desirable attitude took an abrupt turn for the worse during the mastery stage of the project. During the 4th class on mastery (May 16), the group II teacher, disgusted by the group attitude and failure to cooperate, told her group that marks from the

achievement tests would be used on report cards. She read previous achievement marks of individual students to the group. The student response to this declaration is mirrored in diary entries for the day: (May 16)

> Student C: I HATE THIS MATH! The reason I hate this math is because you try and all they care is the mark you get.

> Student T: I HATE THIS MATH AND I WILL NEVER LIKE IT AGAIN!

There were three positive responses to the daily lesson of May 16 found in the diaries, but these were entered by students who had managed relatively good scores on the achievement exercises. All negative comments were aimed at the entire project, as indicated above, and not at a single lesson. The group I students showed no diary entries for that particular day.

The teacher of group II reported the student response to her statement on marks. She said the students who had done poorest, as well as one or two who had done very well on previous achievement exercises, refused to cooperate in any more lessons. They would not finish exercises until threatened with punishment.

A check of the items correct on the mastery achievement test indicates that both groups show a major drop in performance on items after No. 3 for group II and after No. 4 for group I. (See Tables 5.1 and 5.2) It is a very suggestive fact that this sharp drop in performance coincides exactly with the day after which students were told their marks would be recorded on

TABLE 5.1

PERCENTAGE OF STUDENTS RECEIVING FULL CREDIT ON INDIVIDUAL ITEMS OF THE MASTERY ACHIEVEMENT TEST IN GROUP I

Lesson No.	Date	Test Item	% of correct on item
1	May 10	1	.50
2	11	2	.33
3	15	3	.17
4	16	4	.42
5 - 6	17	5 - 6	.08
7	18	7	.08

TABLE 5.2

PERCENTAGE OF STUDENTS RECEIVING FULL CREDIT ON INDIVIDUAL ITEMS OF THE MASTERY ACHIEVEMENT TEST IN GROUP II

Lesson No.	Date	Test Item	% of correct on item
1	May 10	1	.46
2	11 & 15	2	.54
3	16	3	.31
4	17	4	.08
5 - 6	18	5 - 6	.08
7	--	7	.00

report cards. Some students refused to learn when it meant being graded on their performance. It is not known whether this refusal serves as a defense mechanism or simply is a logical reaction by students who know they will fail anyway.

Student-Teacher Relationship and its Effect on the Project

Slow learners in general have a very acute need for teacher approval. It is difficult to determine exactly how this need relates to learning and achievement and whether in fact the slow student-teacher relationship is significantly different in its effect than that of the average ability student. There is some evidence that slow learners, unable to accept a steady diet of failure, use the teacher as a scape-goat. The student failure is then rationalized. He has failed because his teacher "doesn't like him" or the subject under study "doesn't make sense." The student furthermore responds to the lesson in an emotional fashion. Whereas all students undoubtedly are affected by their perceptions of the teacher, with average and above average ability students, the subject is the primary consideration with teacher disposition more of an incidental factor. Evidence from this project suggests that teacher behavior, as perceived by the students, may have a powerful influence on student perception of lesson activities. Following are some entries made by students in their diaries:

> Student C: I liked math today because the teacher was nice today.

Student Kc: I enjoyed the lesson today because we had a new advisor (Dr. Kieren visited the class). Last year the teacher didn't let me do math. She always yelled at me. But you (the teacher) tell us it quite well.

Student M: Today's lesson I did not enjoy because when other people are here I get nervous.

It is quite clear that many of these students respond to teacher and lesson as a unit. It is not known whether this response is modifiable. In view of the above entries it can be concluded that to some of these students the enjoyment of a lesson or activity is directly dependent upon their perceptions of the teacher.

V. SUMMARY

Reasons for incorporating physical activities into an instructional program for low achievers/slow learners fall into two categories: enjoyment and efficiency of learning. This project supports the enjoyment category without reservation. Students from both groups indicated great appreciation for the physical activities and stated a desire to continue the use of such materials. Most saw the materials as facilitating understanding of concepts. As a pilot study, no control group was used and hence no attempt was made to compare achievement under a regular inclusion of physical activities with that of the traditional or textbook approach. One teacher found the activities very exhausting.

Permitting or encouraging students to work in small groups was part of the project. Student response once again was highly favorable. Students were reluctant to talk about answers to be written down at first but this problem eased with time. A tendency to gossip during group-work developed but was generally not considered a serious problem.

The response to using achievement scores as a means of reporting to parents was considerable. Both groups exhibited a significant drop in quality of performance on achievement exercises when they were told marks would be used on report cards. Students were openly rebellious at this time and many refused to participate in the learning experiment any longer. Marking was shown to have a very negative effect on the learning situation for these students.

Students perceived a lesson to be an extension of the teacher herself. Lessons were frequently cited as fun or not fun because the teacher was "nice" or "mean" that day. The student response associated with negative teacher behavior proved to negate any reward intrinsic to the lesson itself. Whereas teacher disapproval of students had a very definite and debilitating effect on student reception of a lesson, teacher approval did not necessarily insure that a lesson would be well received.

CHAPTER VI

SUMMARY, CONCLUSIONS, AND IMPLICATIONS FOR MATHEMATICS EDUCATION AND FURTHER RESEARCH

I. PURPOSE OF THE STUDY

The purpose of the study was threefold. First, it was a pilot study to determine the feasibility of implementing the theoretical program of instruction for slow learners in a long term comparative study. Secondly, three variables were studied to determine the effect of each on the instructional program and to determine their subsequent incorporation into the instructional program. Finally, the study was designed to determine those student and teacher characteristics which most strongly influenced the learning process in the given situation.

The instructional program was synthesized from existing theories in developmental psychology and mathematics instruction and based on needs peculiar to the slow learner. The three variables studied included:

1. teacher demonstration
2. mastery of daily lessons
3. socially relevant activities.

An analysis of student behavior during the project was undertaken to provide a basis for modification or extension of

the theoretical program. In addition to the three variables mentioned, the study included an analysis of student response to certain fundamental elements on which the instructional program was founded. The single most important was the physical activity factor. Student response to activities was recorded in student diaries and by the researcher during personal interview.

Student response to group work was studied to determine feasibility of permitting group work on a regular basis. The literature reveals a strong psychological case for permitting students to work in groups since it permits them to exchange and clarify ideas. Studies with slow learners indicate they may not be able to cope with such grouping. The present project was used to shed light on this problem.

The design of the project was structured so that it would be possible to study student responses of a non-academic nature. Such responses might be expected to reveal effects of the conceived sequence and hence lead to alterations in the sequence.

II. FINDINGS OF THE STUDY

The findings of the study fit two general categories. The first includes treatment of variables in the instructional program and is cognitive in nature. Second is the affective category which includes student's personal feelings about the method as well as student characteristics which either facilitated or hindered learning.

Specifically, the major findings were:

1. An analysis of the teacher demonstration variable yielded a need for expansion and redefinition to include two subsets. One, the instructions to be followed, and questions to be answered during the activity, should be presented prior to each lesson. Two, a statement of the existing relationships and concepts should be presented following the lesson.
2. In teaching for mastery of daily concepts it was found that students do perform at a higher level on items which test their retention. Performance on items which tested concepts of lessons studied by the non-mastery group but not the mastery group was not adequate to explain differences in over-all achievement scores.
3. Activities of a socially relevant nature were found to be more meaningful to students. Students were able to relate the activity structure to the mathematical structure in the social relevance setting but were unable to make the transfer from the purely laboratory setting.
4. The activity approach to all lessons (using concrete materials) was perceived by students to be enjoyable and an efficient way to learn. They felt they understood questions better and were able to answer them more easily when using physical aids.
5. Grouping to permit students to discuss activities and

exchange ideas was found to increase enjoyment.

6. The convention of using scores from achievement tests to indicate progress on report cards had a very undesirable effect on students: many of them stopped participating and cooperating in the lessons.
7. Students found lessons enjoyable or not depending upon how "nice" they thought the teacher was during the lesson.
8. Virtually all students stated a preference for the instructional methods used during the project over that which had been used before; ie., a textbook, independent study approach.

III. CONCLUSIONS AND IMPLICATIONS FOR MATHEMATICS EDUCATION

In view of the above findings it is possible to arrive at a number of directed statements and their implications for the teaching of mathematics.

Teacher Explanation/Demonstration

Findings for the teacher demonstration variable suggest a need for clear, concise and simple instructions for each lesson activity. This should include some indication of relationships which should emerge from the activity. Given prior to a lesson, teacher explanation/demonstration functions

to clarify procedures to be followed and why they are being carried out. A statement of relationships which do exist and concepts which will be developed is best left until the activities have been completed. There is some evidence to suggest that students do not attach meaning to statements of specific relationships or concepts of an abstract nature when they are presented prior to the lesson. Furthermore, students who are permitted to actively involve themselves with the abstractions are more apt to ask questions when statements are given following the activities. A certain amount of confusion and need for clarification existed following the activities which resulted in a more meaningful learning situation for the students when statements were made by the teacher.

Mastery of Daily Lessons

Findings for the mastery phase of the project were somewhat colored by the duration of the phase and the response to marking of report cards which occurred at that time. The degree of frustration and boredom which existed in both groups and the very low group means suggest that students should probably not be rushed through lessons under any circumstances. Superiority of performance on the lesson which was reviewed by the mastery group is sufficient to justify the expenditure of time necessary to insure mastery. It is difficult to assess the meaning of performance on the last two mastery lessons and test items but it appears that the topic (concept) covered in a

lesson by the non-mastery group did not add significantly to their achievement scores as compared with those of the mastery group which had not covered the concept in question. There is a reason to believe a cumulative effect does exist and this does favor teaching lessons for mastery of the concept involved.

The decision to determine mastery of a given lesson by completion of daily exercises was inadequate. One cannot assume retention because daily exercises are complete. In the future, it would be wise to arrange a testing tool to be administered following a lesson and preferably a day later. This would ensure deletion of such confounding factors as "copying" exercises from another person in the group and hence showing false mastery.

In comparing student opinion of daily lesson to results of achievement test it can be seen that students do not appear to be aware of what they have or have not learned. They indicate frustration and boredom but only rarely do they see the cause to be an inability to comprehend what is going on.

Socially Relevant Activities

Findings from the social relevance phase of the project were based to a great extent on accuracy of student transfer of activity model to mathematical structure. Students who were aware that a specific model was unalterable (the Postman Stories group) were considered to be learning in a more meaningful way

than students who believed it was acceptable to alter the activity to make it easier. The latter students (those using the game approach) were unaware of the abstractions involved and could not be expected to abstract correctly unless the activity model remained as presented. Carrying this a step further, students felt free to alter the game because it had no real meaning to them. The rules were simply rules and anything that might make the game more fun was considered permissible. With the Postman stories, a very relevant model, such facts as being happy when the postman brings a check are both personally meaningful and unalterable. The case is a good one for inclusion of contexts to which students can easily relate.

The Optimum Instructional Sequence

In terms of the findings and conclusions stated above, the instructional program can be defined with respect to the teacher explanation/demonstration variable. The sequence for introducing a concept to slow learners at the grade 7 and 8 level will be as follows:

1. Teacher will give detailed instructions to be followed during the lesson activity. This will include a statement of the problem to be solved (questions to be answered) by the students.
2. Physical embodiments will be presented as activities to be discussed and symbolic representation will be

introduced at that time.

3. Teacher will summarize the findings and give a statement of relationships or concepts developed during the activity.

Lesson Activities

The activity involved with each lesson was unquestionably enjoyed by the majority of students. In terms of possible long term effect on attitude it would be considered desirable to continue including activities to be carried out by students during each lesson. There is another function of the inclusion of activities, that of concrete embodiment. Slow students at the sample age level are not often able to comprehend symbolic representations. The physical manipulations provide a more compatible mode for them. Furthermore, many students claimed they remembered physical objects from a previous lesson and used those mental images to help with a new and more complex activity. Inclusion of physical activities on a regular basis is desirable because it provides the student with something he finds easy and enjoyable and, more important, an efficient way for this study to learn mathematics.

Grouping

During the present study students were permitted to work in groups of two or three students. They were encouraged

to discuss activities and answers and to explain why they believed an answer to be correct or incorrect. There was some abuse of the talking but neither teacher felt the problem serious. Characteristically, slow learners are not thought to have the self-discipline necessary to work effectively in groups. There was no evidence to support that belief in the present study. Student response to group work was based on the sociability factor--they enjoyed working with friends. This is not seen as a problem. If students are informed of the necessity for conscientious group work and the consequences of abusing the opportunity, they can be expected to perform as well in groups as they do independently.

Student Response to Discipline

In noting student comments in the diaries, one theme was seen to repeat for many students. Their perceptions of lessons were related directly to their feelings toward the teacher on that particular day. This finding is very difficult to correct for since most teachers would not punish a student without good reason. Obviously, certain forms of discipline are taken personally by the students. An attempt should be made to use disciplinary measures which do not carry personal stigma. A counter-example would be the use of marks to punish inattentiveness. In essence, this action was placing a value on the student personally. This problem of associating

lessons with teacher disposition is greatly dependent upon the fact that the student is unable to separate himself from his action. Where a teacher may be punishing a bad action the student reacts as though he were "bad." Students must be made aware that they, as individuals, are not disliked. Only then will they be able to respond to an act of discipline for what it is--an action on a behavior, not a whole personality.

IV. IMPLICATIONS FOR RESEARCH

The overall response to the pilot program suggests the desirability for further research with the proposed program of instruction for slow learners. A comparative study involving the instructional program would be expected to involve at least one semester of full-time implementation. The development of an appropriate series of lessons would be necessary before the comparative study was carried out and this would be expected to involve perhaps a semester of piloting and modification. Clearly, a series of lessons to which the proposed sequence might be fitted doew not exist.

The inclusion of physical materials has been recognized as beneficial to slow learners but the question remains of how often and how many activities involving physical materials should be used. It is possible that with some concepts <u>only</u> physical materials would suffice for students at the junior high level. Studies are needed which will determine topics

which are taught best using physical embodiments and those which may be handled symbolically. It is hypothesized that students are able to make the transfer from concrete to abstract--as evidenced by performance on achievement tests. However, it is not known when the transition takes place--at what stage of the lesson or activity--if at all. If the transition has taken place is it then safe to assume that more complex concepts and relationships, built on previously learned ones, can effectively be taught without concrete materials? Will the mental images stored from previous lessons suffice to build with? Although it would probably do no harm to incorporate physical activities even when they are not necessary for learning, such an inclusion could prove unnecessarily time-consuming.

The proposed program was conceived specifically for slow learners. Many schools maintain heterogeneous classes and teach to the average ability child. The method described in this paper could prove flexible enough to satisfy average students while filling the needs of the slow learner. Implementation in a regular classroom could be studied and would provide feedback as to special considerations necessary for regular use with a heterogeneous group.

Very serious considerations must be given the present marking system and its effect on slow learners. Studies should be designed which permit comparison of achievement scores for students under systems which compare them with other students and systems which compare them with themselves. Students are

often forced to become disruptive as the only honorable way of failing. Even the slow learner knows, perhaps better than other students, that it is stupid to do one's best and fail when one can do nothing and fail equally well. The full effect of this attitude on achievement and success has yet to be determined.

A very valuable study would involve the achievement score effects of student-teacher relationships and perception of lessons. We have observed during this study that students do not like a lesson when they think the teacher has been "mean." A well designed study would correlate test items and lessons done when the teacher was "mean" as compared with test items and lessons when students thought the teacher was "nice."

Studies carried out on any aspect of the cognition of the slow learner must be done in the context of the slow learner reality. It is an exercise in futility to expect the slow learner to respond to situations where values and abilities of "model" students prevail. That which is real and meaningful to the slow learner must be determined and systems of reinforcement developed to accommodate those values.

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APPENDIX A

SAMPLE LESSON ACTIVITIES

AND EXERCISES

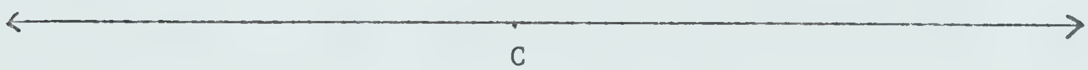
LESSON #9

(from Phase I)

Name: grade:
group:
date:

Materials: 2 triangular models cut from construction paper. 1 red and 1 blue.

I. Tear the angles off your large triangle and arrange them around the point "C" above the line below. Be sure the <u>vertices</u> point toward the point "C". Tape them down. Repeat this process using your second triangle but this time arrange the vertices <u>below</u> the line.



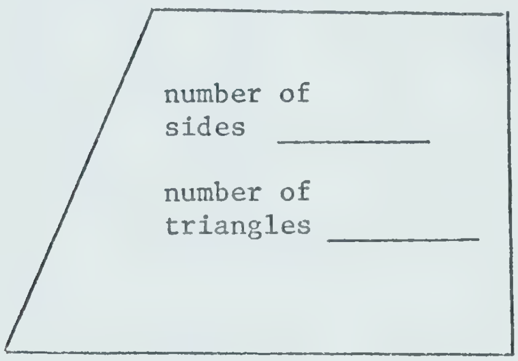
II. What can you tell about the total number of degrees in the angles of each triangle? ____________ How many degrees were there in the other student's triangles? ____________

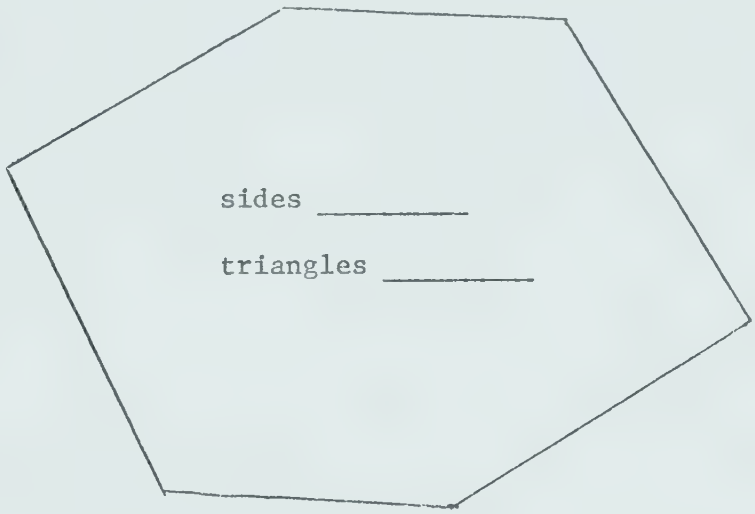
LESSON #15

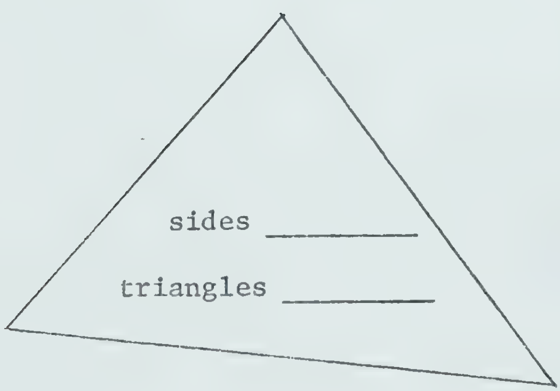
(from Phase II)

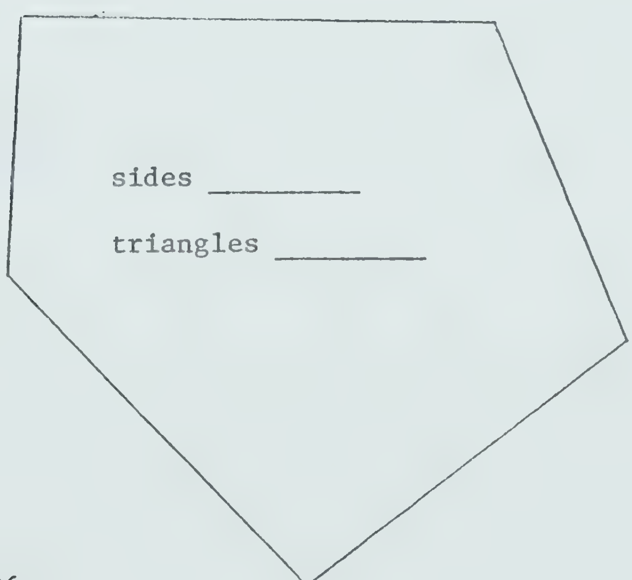
Name: grade:
group:
date:

I. For each polygon on these three pages, draw a diagonal <u>from one vertex</u> to all the other vertices. How many triangles have been formed in each case?

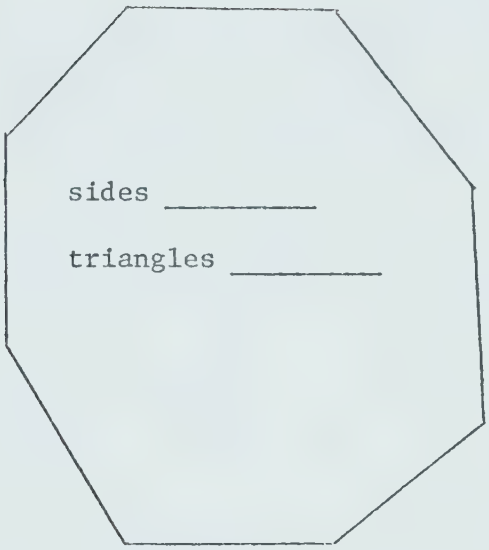


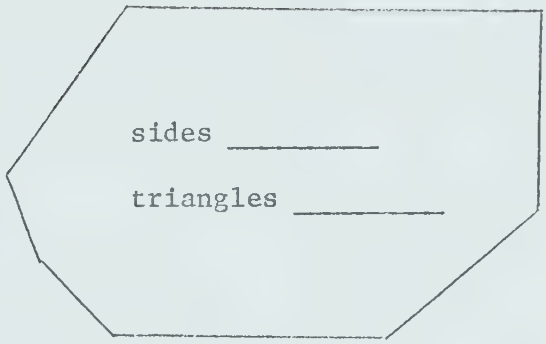


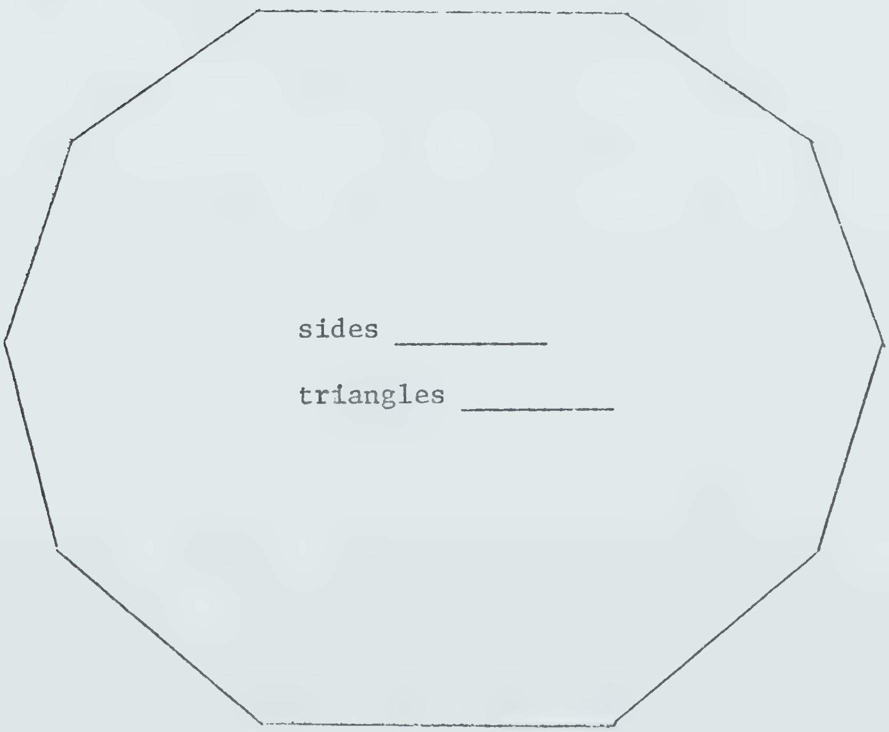




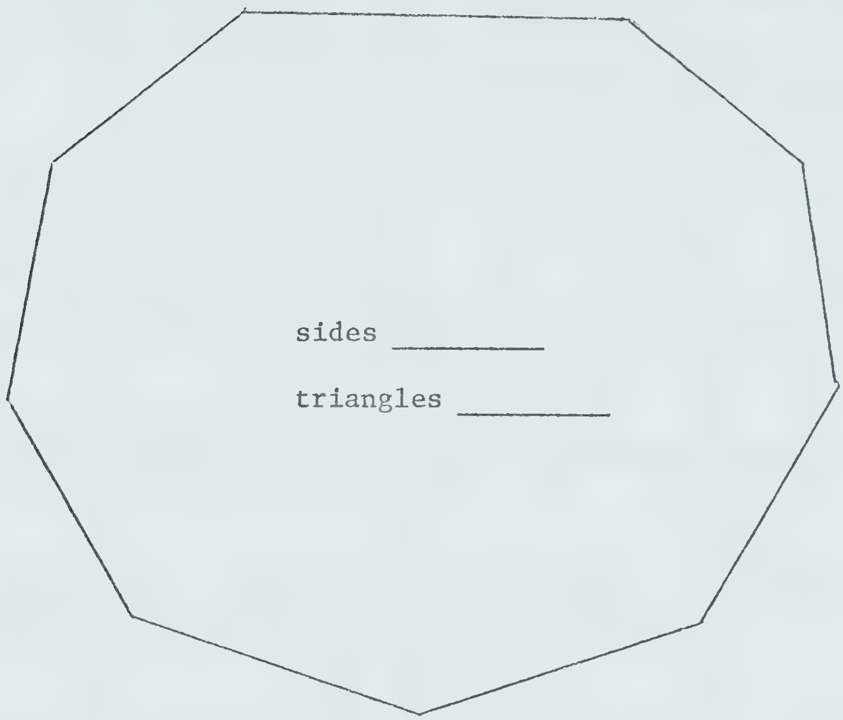
Name: grade:
group:
date:







Name: grade:
group:
date:



Name: grade:
group:
date:

Name of Polygon	Number of Sides	Number of triangles formed	Sum of angle measures
triangle	3	1	$1 \times 180^{\circ} = 180^{\circ}$
4 - gon Quadrilateral	4		
5 - gon Pentagon	5		
6 - gon Hexagon	6		
7 - gon Heptagon	7		
8 - gon Octagon	8		
9 - gon Nonagon	9		
10 - gon Decagon	10		

I. Subtract the number of triangles formed from the number of sides for each polygon. What do you get?

II. How many triangles would be formed with a 20-gon? (20 sided polygon)

__________.

How many degrees would there be in the total angle measure?

__________.

LESSON #20

(from Phase III)

Postman Stories

(a model for operating on integers)

Name: grade:
group:
date:

I. We will be talking about checks and bills. What is a "check"? What is a "bill"?

II. We will always use a + sign to mean a check. A $^{-}$ sign will mean a bill. These are called "positive" (+) and "negative" ($^{-}$).

a check for \$5 is written: $^{+}5$
a bill for \$5 is written: $^{-}5$

III. The postman (mailman) <u>brings</u> checks and bills.

When he <u>brings</u> a <u>check</u> for \$5
we write: $+{}^{+}5$

When he <u>brings</u> a <u>bill</u> for \$5
we write: $+{}^{-}5$

IV. Sometimes the postman <u>takes</u> checks or bills <u>away</u> from us.

When he <u>takes</u> a <u>check</u> for \$5
we write: $-{}^{+}5$

When he <u>takes</u> a <u>bill</u> for \$5
we write: $-{}^{-}5$

Name: grade:
group:
date:

I. Would you be happy if the postman took back a check? ________

Would you be happy if the postman took back a bill? ________

Would you be happy if the postman gave you a bill? ________

Would you be happy if the postman gave you a check? ________

II. Below are some things the postman did on certain days. Can you tell whether he brought checks or bills? What happened on each day? Are you happy or sad?

Monday $+\,^{+}6$

Tuesday $+\,^{+}3$

Wednesday $-\,^{+}3$

Thursday $+\,^{-}4$

Friday $+\,^{-}6$

Monday $+\,^{+}7$

Tuesday $-\,^{+}6$

Wednesday $+\,^{+}5$

Thursday $+\,^{+}3$ $-\,^{+}5$

Friday $-\,^{+}7$ $+\,^{+}4$

Name: grade:
group:
date:

I. Beginning on Monday, you have a balance of \$20 in your house. Tell what happens on each day and how much you have left at the end of the day.

Monday: \$20

$+3 + {}^{+}5$

are you richer or poorer? How much?
How much will you have on Tuesday? _______

Tuesday: _______

${}^{-}3 + {}^{-}4$

are you richer or poorer?

Wednesday: _______

$+4 + {}^{-}6$

what did the postman do?

Thursday: _______

$+7 + {}^{-}3$

what did the postman do?

Friday: _______

${}^{-}4 + {}^{-}6$

what did the postman do?

Monday: _______

${}^{-}8 - {}^{+}5$

II. What is your balance on Monday night?

APPENDIX B

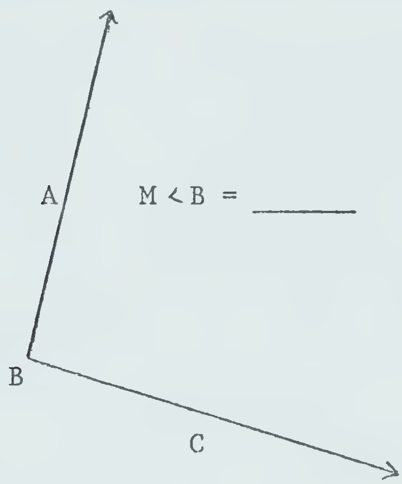
ACHIEVEMENT TESTS

ACHIEVEMENT TEST #1

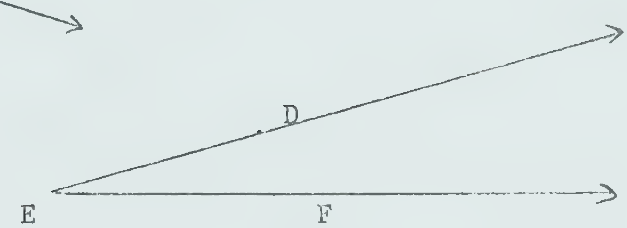
(Phase I)

Name: grade:
group:
date:

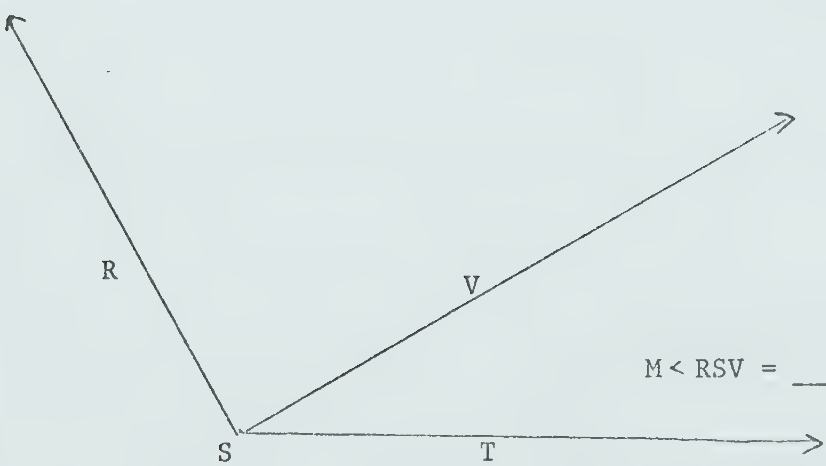
I. Find the measure of each angle below.



M < B = ______



M < E = ______

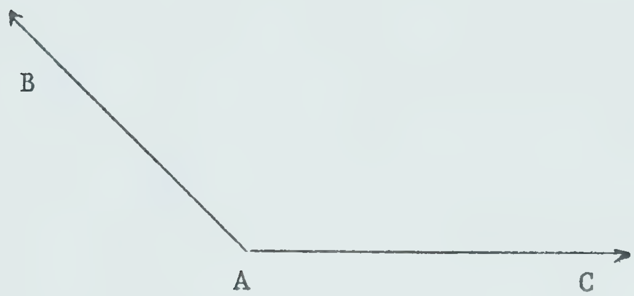


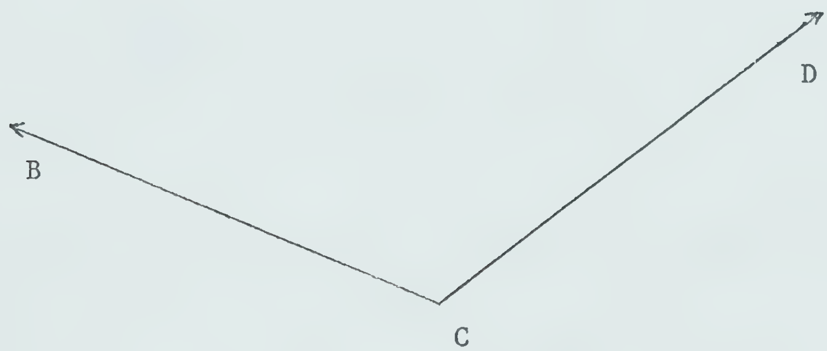
M < RSV = ______

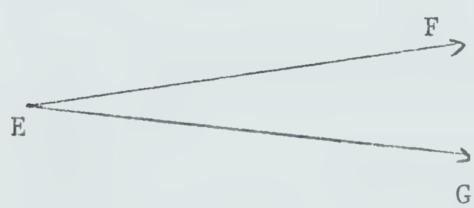
Name: grade:
group:
date:

II. Given the following angles:

1) Name all the <u>acute</u> angles.
2) Name all the <u>obtuse</u> angles.
3) Which angles did you need your protractor to measure before you could tell whether it was acute or obtuse? ________________

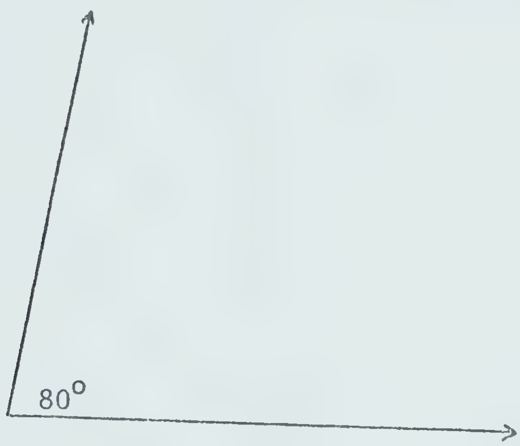


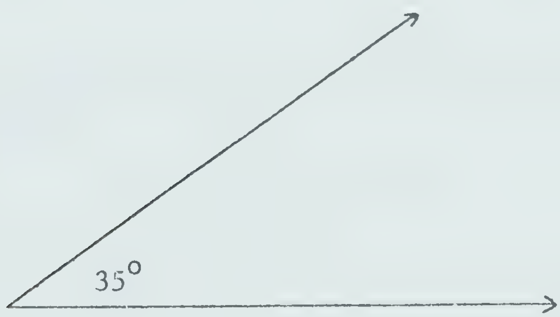




Name: grade:
group:
date:

III. Given the angles below, tell how many degrees in the complement of each. ______________
How many degrees in the supplement?

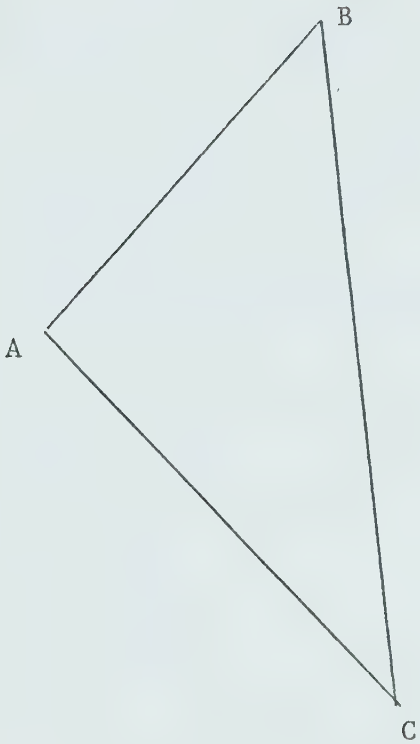




IV. Given the triangles below, name the sides and angles of each.

side	Angle
______	______
______	______
______	______

Name: grade:
group:
date:

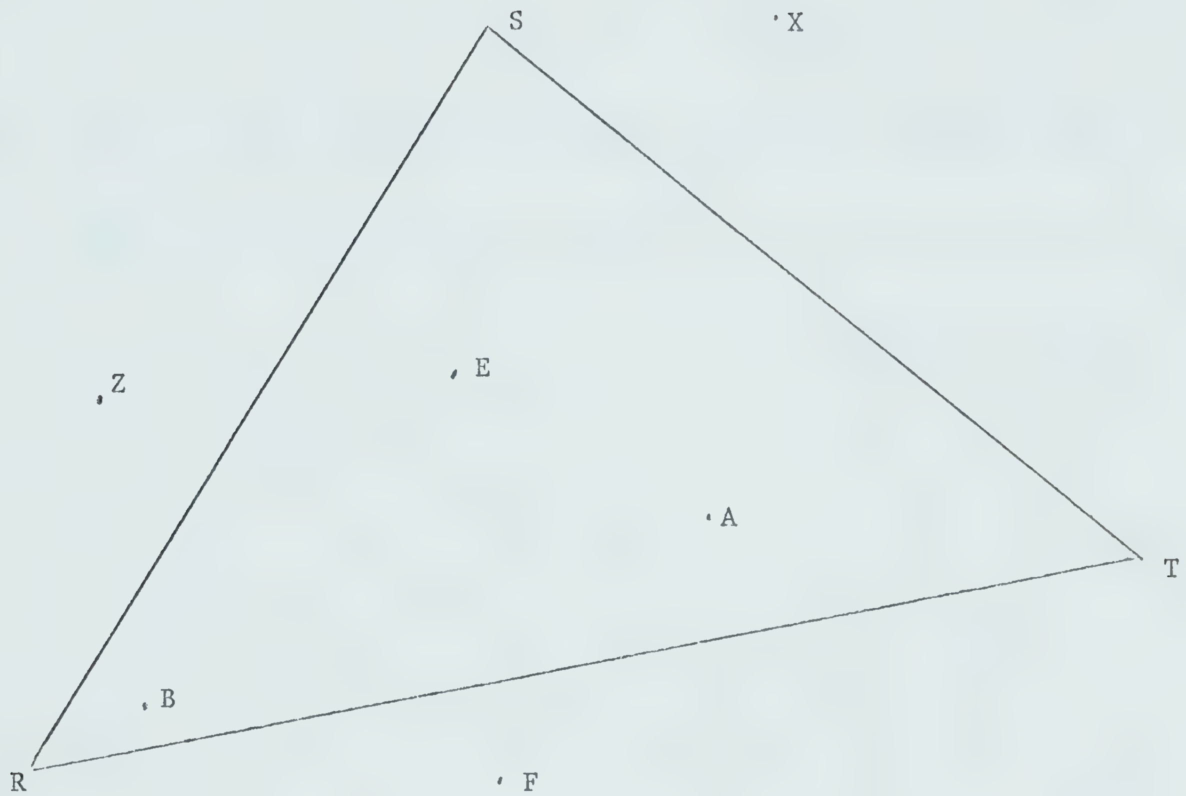


side	Angle
______	______
______	______
______	______

V. You have been given two cardboard angles. Can you make a triangle? If so, sketch the triangle.

VI. Given the triangle RST below, answer the following questions about the triangle.

Name: grade:
group:
date:



1) Which points shown are in the <u>interior</u> of the triangle? ______

2) Which points are in the <u>exterior</u>? ______

3) Which points are <u>on</u> the triangle? ______

4) Which points are in the <u>interior</u> of <u>$\angle R$</u>? ______

ACHIEVEMENT TEST #2

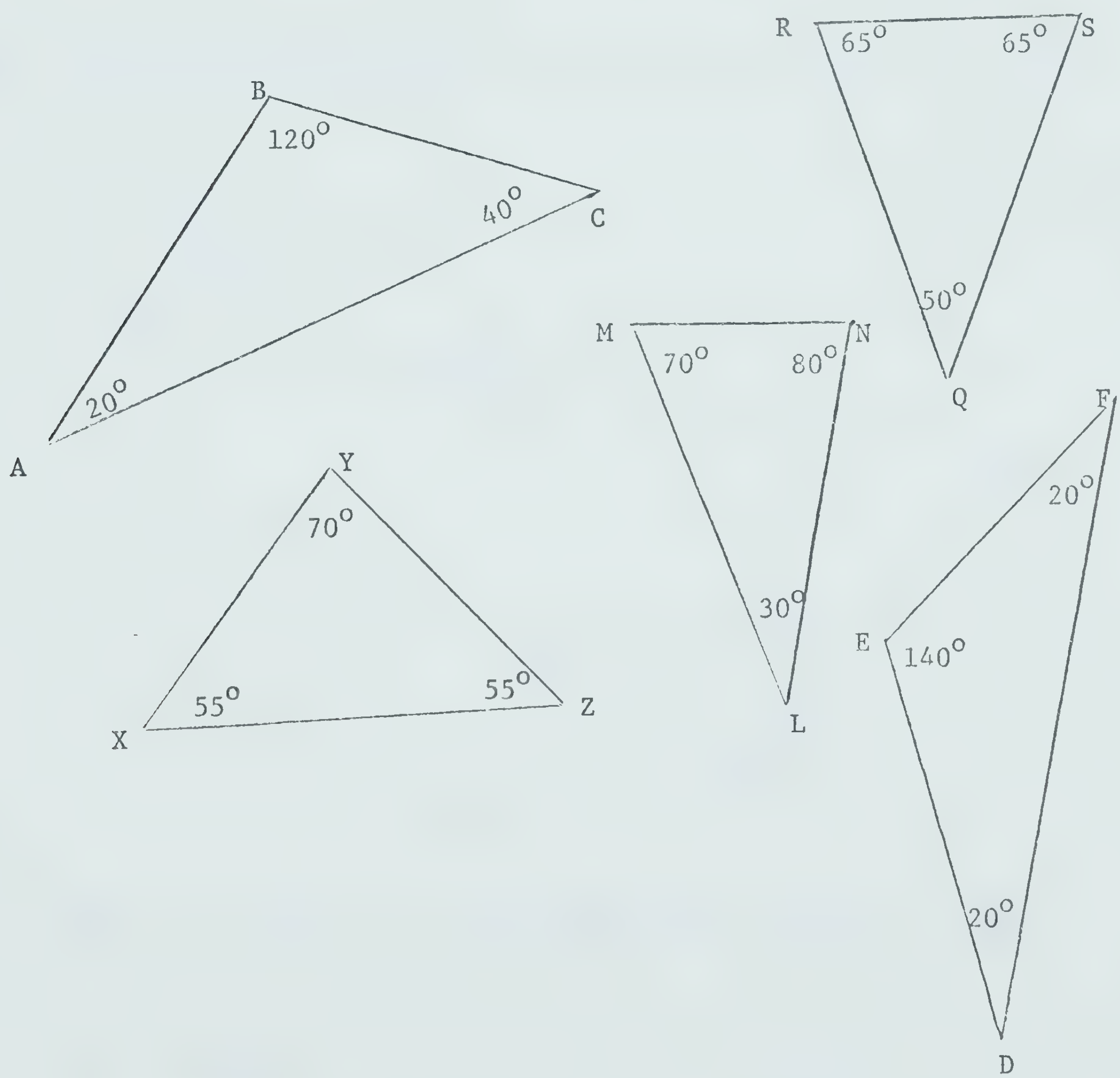
(Phase I)

Name: grade:
group:
date:

I. Look at the triangles below. Which triangles are <u>acute</u> triangles?

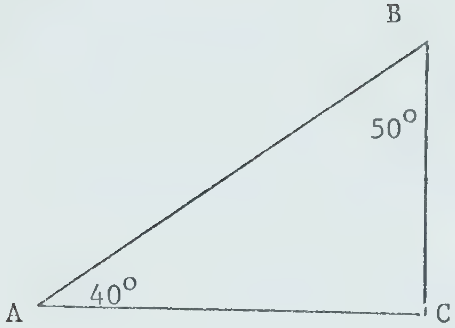
____

Which triangles are <u>obtuse</u> triangles? _____________________

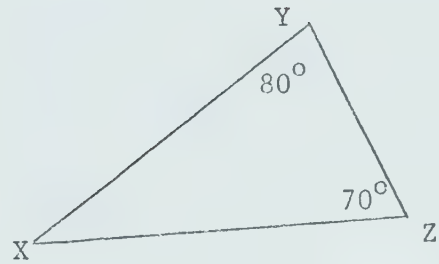


II. Look at the triangles below. How many degrees are there in the <u>missing</u> angle measures?

Name: grade:
group:
date:

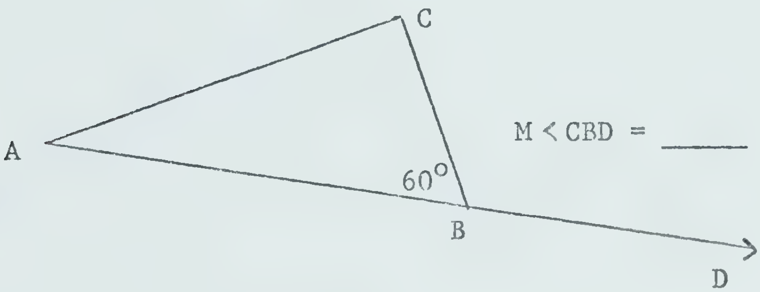


M < C = ______



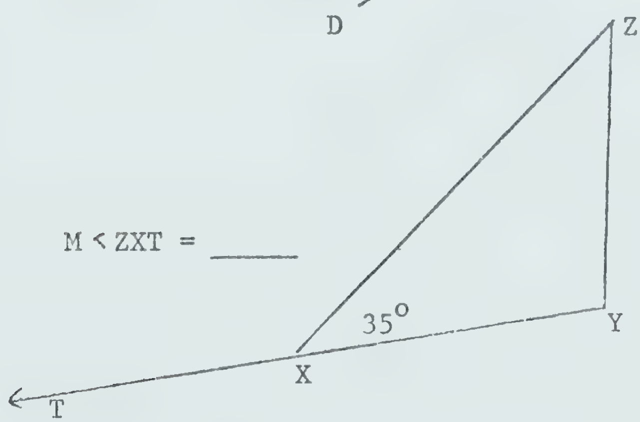
M < X = ______

III. How many degrees are there in the <u>exterior</u> angles shown below?

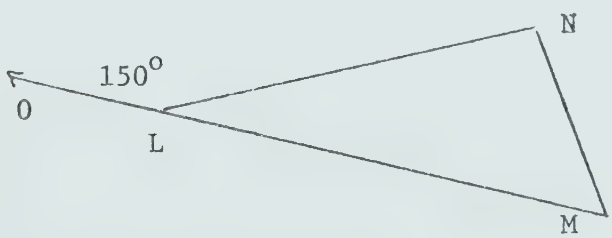


M < CBD = ______

M < ZXT = ______

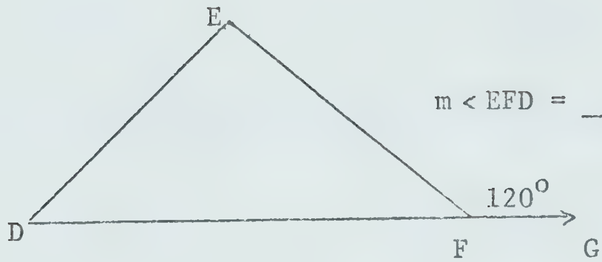


IV. What is the measure of each <u>interior</u> angle indicated below?



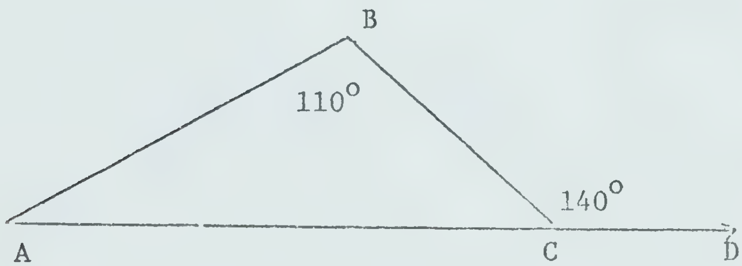
m < NLM = ______

Name: grade:
group:
date:

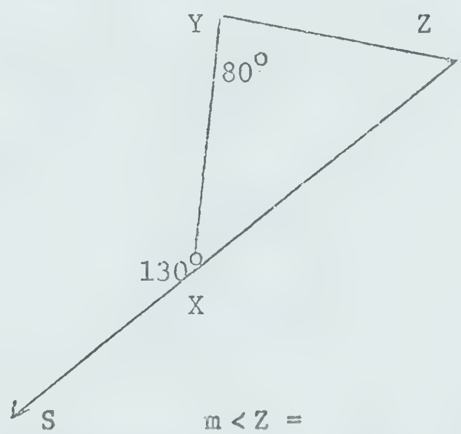


m < EFD = ______

V. Look at the triangles below. Find the angle measure for each <u>remote interior</u> angle indicated.



$\angle$ A = ______



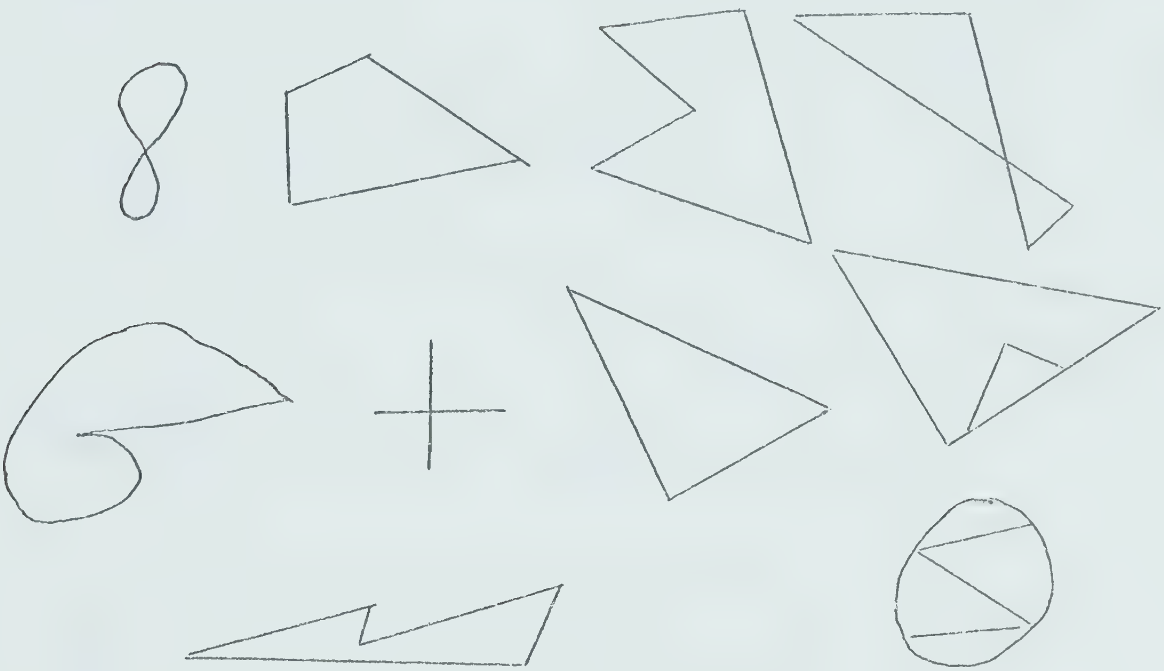
m < Z = ______

ACHIEVEMENT TEST #3

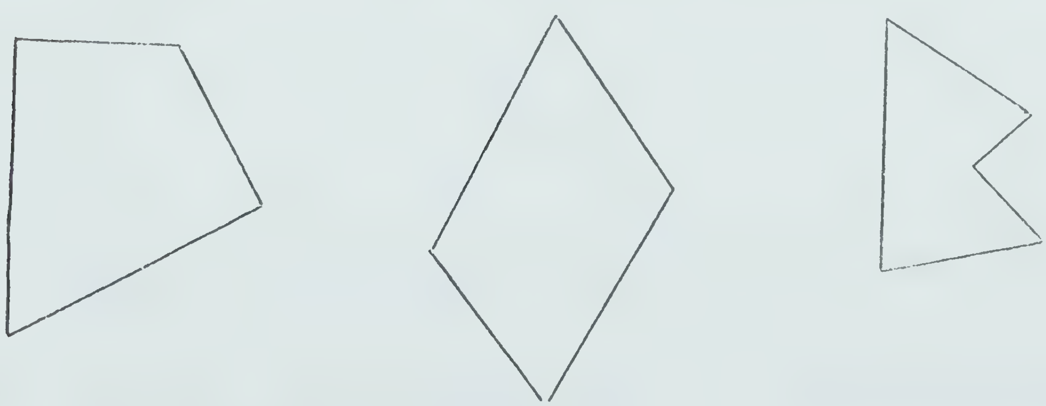
(Phase II)

Name: grade:
group:
date:

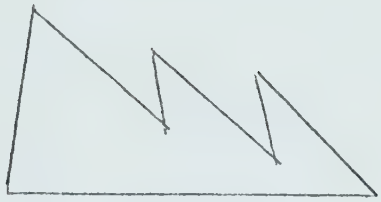
I. Below is a group of figures. Circle all the polygons.

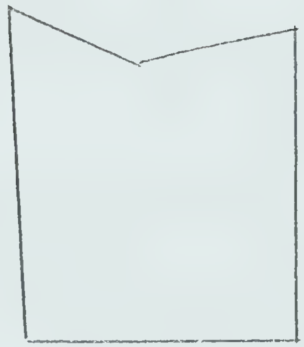


II. Which of the figures shown below are <u>convex polygons</u>? Circle your answers.

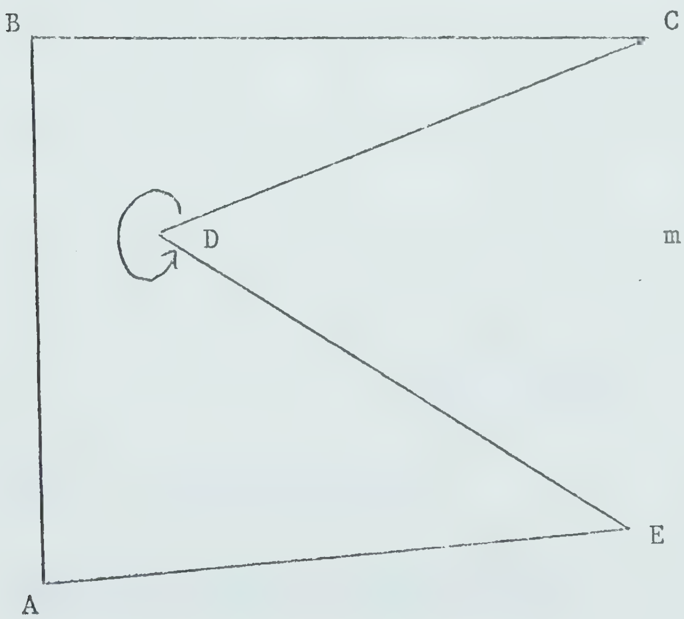


Name: grade:
group:
date:





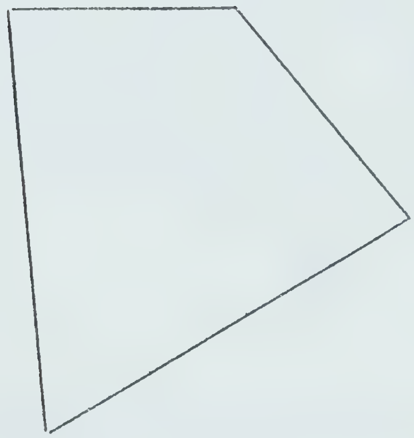
III. What is the measure of the <u>interior</u> angle shown below?

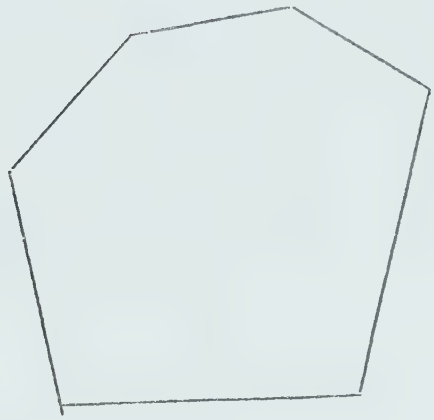


$m \angle CDE =$ ______

IV. Below are a group of polygons. What is the <u>total angle measure</u> for each? Show how you got your answer.

Name: grade:
group:
date:





total measure = ______

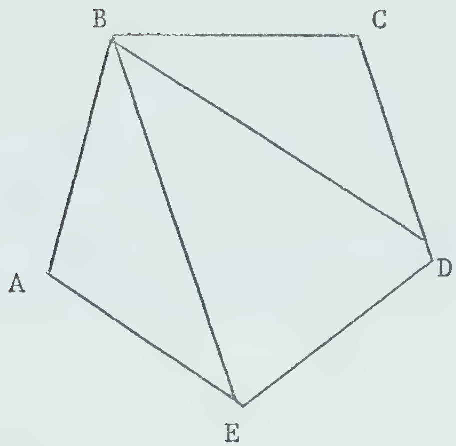
total measure = ______

total measure = ______

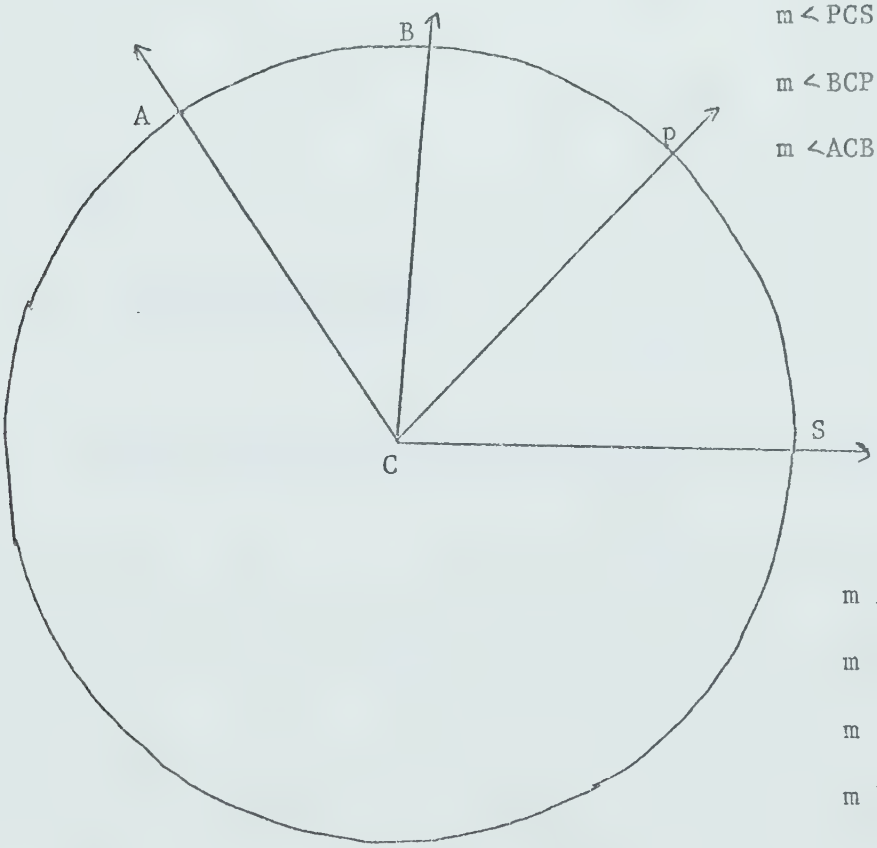
V. What is a Regular Polygon?

VI. Below is a regular Polygon. Find the measure of one angle. Do not use a protractor. Show your work.

Name: grade:
group:
date:



VII. You are given the measure of each <u>central angle</u> below. What is the measure of each <u>arc</u> indicated?



$m\angle PCS = 47^\circ$

$m\angle BCP = 40^\circ$

$m\angle ACB = 39^\circ$

$m\angle ACS = 126^\circ$

$m\,\widehat{AB} =$ ________

$m\,\widehat{AP} =$ ________

$m\,\widehat{BS} =$ ________

$m\,\widehat{PS} =$ ________

ACHIEVEMENT TEST #4

(Phase III)

Name: grade:
group:
date:

I. Measure all objects to the nearest ¼".

1. string _____?
2. straight edge of your protractor _____?
3. top edge of your brown envelope _____?
4. The following segments:

A ______________________________ B   m $\overline{AB}$ = ________

D ________ E   m $\overline{DE}$ = ________

X ____________________________________ Y   m $\overline{XY}$ = ________

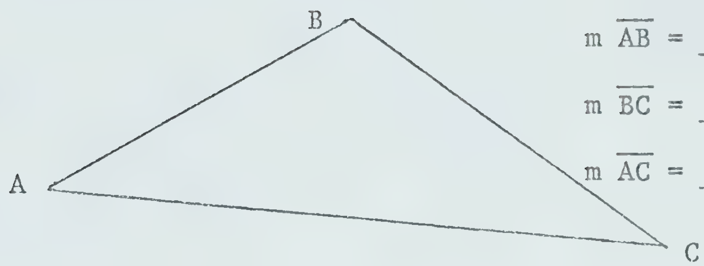
II. Measure all sides to the nearest ¼".

1. The sides of your green diary ______?
(Measure all sides) ______
______
______

2. The sides of the white card ______?
______
______
______

3. The sides of the following figures:

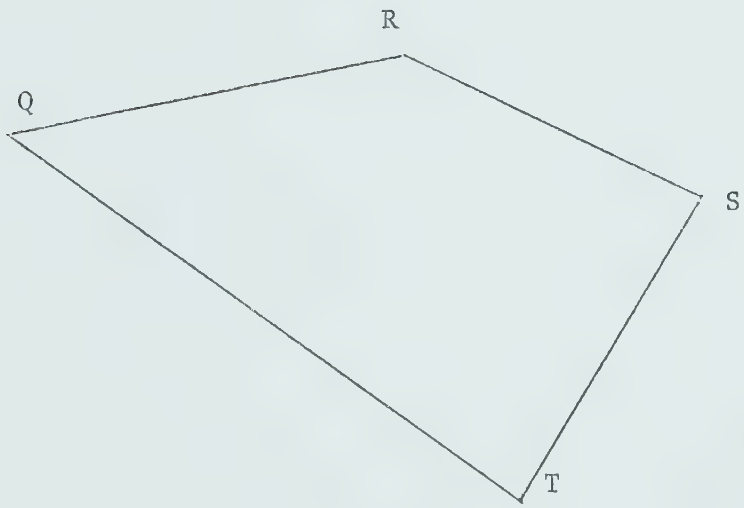
Name: grade:
group:
date:



$m\ \overline{AB} =$ ______?

$m\ \overline{BC} =$ ______?

$m\ \overline{AC} =$ ______?



$m\ \overline{QR} =$ ______

$m\ \overline{RS} =$ ______

$m\ \overline{ST} =$ ______

$m\ \overline{QT} =$ ______

4. a) What is the perimeter of your green diary? What does it measure? ____________

   b) What is the perimeter measure of the brown envelope? ________

   c) What is the distance around $\triangle ABC$? __________

   d) What is the perimeter of figure QRST? __________

   e) How did you find the answers to 4a, b, c, d?

ACHIEVEMENT TEST #5

(Phase III)

Name: grade:
group:
date:

I. Find the answers to the following:

a) $+4 + {}^{+}2 =$ _____

b) $+4 - {}^{+}2 =$ _____

c) $+4 - {}^{-}2 =$ _____

d) $-2 + {}^{+}4 =$ _____

e) $+6 - {}^{+}3 =$ _____

f) $-6 - {}^{+}3 =$ _____

g) $-3 - {}^{+}6 =$ _____

h) $+3 - {}^{+}2 =$ _____

i) $+3 - {}^{-}2 =$ _____

j) $-3 - {}^{-}4 =$ _____

k) $+7 - {}^{-}6 =$ _____

l) $-15 + {}^{-}3 =$ _____

II. What did you like about the lessons on using the ruler?

What did you dislike?

III. Did you like the lessons that showed how to add and subtract negative and positive numbers? <u>Why</u>?

APPENDIX C

STUDENT SCORES

GROUP I

I.Q. SCORES AND PERCENTAGE SCORES ON THE FIVE ACHIEVEMENT TESTS FOR INDIVIDUAL STUDENTS

ID	IQ	Phase I week 1	Phase I week 2	Phase II (Mastery)	Phase III (measurement)	Phase III (operations on integers)
1	102	50	80	45	--	--
2	84	50	25	65	64	50
3	101	61.2	65	60	54	44
4	90	44.4	55	19	60	25
5	70	44.4	20	5	40	44
6	78	72.3	60	19	--	--
7	81	61.2	95	21	68	18
8	90	27.8	55	42	--	--
9	78	91.6	60	55	94	75
10	77	91.6	55	63.2	70	18
11	88	94.4	90	65	64	75
12	62	50.0	30	26.3	56	25

GROUP II

I.Q. SCORES AND PERCENTAGE SCORES ON THE FIVE ACHIEVEMENT TESTS FOR INDIVIDUAL STUDENTS

ID	IQ	Phase I week 1	Phase I week 2	Phase II (Mastery)	Phase III (measurement)	Phase III (operations on integers)
13		77.8	100	36.8	76	50
14		44.4	85	21	76	50
15		33.4	80	26.3	--	--
16	93	33.4	10	29	76	25
17	87	50	30	15.8	68	12
18	56	61.2	85	15.8	84	37
19	80	77.8	60	24	--	--
20	93	55.6	75	40	52	25
21	82	61.2	80	--	72	25
22	75	77.8	75	31.6	16	12
23	92	66.8	70	31.6	56	81
24	85	77.8	75	--	80	25
25	91	66.8	35	45	72	0
26	89	81.0	80	34	32	37
27	83	88.8	100	--	84	75